PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

GENERAL LIBRARY JAN 14 1921 UNIV. OF MICH.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2

VOL. CX.—No. 2870.] LONDON: FRIDAY, DECEMBER 31, 1920. [Registered at the General Post Office as a Newspaper.] PRICE 1s. 2d. BY FOREIGN POST 1s. 4½d.

JAN 14 1921

Aveling & Porter, Ltd.,
ROCHESTER.
9537
Steam Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, pages 31 and 83.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Rubber MANUFACTURERS
Valves and Packings
GUTTA PERCHA & RUBBER, LIMITED.
Toronto Canada. 8510

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 8307

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 7411
See Advertisement last week, page 117.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9063

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 8308

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17. 8306

Petter Oil Engines.
Manufactured by 3591
PETTERS LIMITED, Engineers, Yeovil.

"Spencer-Hopwood" Patent Boilers. *See page 15.*
Sole Makers:
SPENCER-BONECOURT, LTD., 8421
Parliament Mansions, Victoria St., London, S.W.

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 9026
REDDISH.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY 1834
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C. 3.

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 36, Robertson Street, Glasgow.
See Advertisement page 90, Dec. 24.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 8708
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 12 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3561
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO.,
50, Wellington Street, Glasgow. 8819

OIL FUEL APPLIANCES.
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street,
Liverpool; and
MESSRS. BUCKNALL & RICHES,
8, Southampton Row, London, W.C.1.
Telephone No.: Museum 6664.
Naval Outfits a Speciality.
4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2467
See their Illus. Advertisement, page 125, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 2383

The Cambridge and Paul Instrument Co. Ltd.,
Manufacturers of Mechanical and Electrical Instruments of Precision.
Head Offices and Showrooms
45, GROSVENOR PLACE, LONDON, S.W. 1.
Works: London and Cambridge. 8194

Henry Butcher & Co.,
VALUERS AND AUCTIONEERS
to the
ENGINEERING AND ALLIED TRADES.
ALSO FOR
PLANT AND MACHINERY. 8134
62 and 64, CHANCERY LANE, W.C. 2.

Electric Lifts
(UP TO 35 TONS.)
9026
S. H. HEYWOOD & CO., LTD.
REDDISH.

Willson
STRAIGHT-BED, GAP-BED,
TOOLROOM LATHES.
Whatever your lathe requirement communicate with us. Our lathe experience and reputation is world-wide. There's a quarter of a century of LATHE SERVICE back of every transaction.
SMITH BARKER & WILLSON LTD.,
North Moorside, Halifax.
Phone: 46. Wire: "Lathe," Halifax.
F 596

FOR
Railway Wagon Couplings
and GENERAL SMITHY WORK,
write
8196
WELDLESS CHAINS, LTD., Cambridge.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1316
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES.
HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 76. 8137

CO_2 Plants (CARBON DI-OXIDE)
for Chemical Wks., Mineral Water Mfrs., Breweries, and all other purposes.—SPARKLETS AND GENERAL MFG. Co., Ltd., Edmonton, London, N. 18. 7996

Die Finished Castings
ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to SPARKLETS AND GENERAL MFG. Co., Ltd., Edmonton, London, N. 18. 7996

For Sale.—
MOTOR-DRIVEN
PLANING MACHINE
To plane 30 ft. by 20 ft. by 10 ft., four Tool Boxes. Condition as new. Makers, Buckton & Co.
Price and particulars from—
MURRAY, McVINNIE & CO., LTD.,
Mavisbank Quay,
Glasgow. 8749

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1900.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 7991

CHANTIERS & ATHLIERS
Augustin-Normand
67, rue de Perrey—LE HAVRE
(France).
3690
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 8690

Electric Cranes.
9026
S. H. HEYWOOD & CO., LTD.,
REDDISH.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW, LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 8237

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 8147
Registered Offices: Clutha House, 10 Princes St., Westminster, London, S.W. 1.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS,
WATER SOFTENING and FILTERING. 8722
Row's Patents

Yarrow Patent Water-tube Boilers.
8709
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9053
See Full Page Advt., page 64, Dec. 10.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 55. 2469

Taylor & Challen Presses.
8195
TAYLOR & CHALLEN, LD., Engineers, Birmingham.
See Full Page Advertisement page 76, Dec. 10.

Diesel Engines, Six Cylinder,
two and four stroke, 880, 1000, 1200 H.P. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price.
Also 2-500 Kw. PARSONS TURBINE SETS 250 or 500 Volts, D.C., with Con. Jenser and spare armature.
ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts, D.C. Pressures 1500 to 3000 lbs. per square inch.
JENNINGS,
West Walls, Newcastle-on-Tyne. 8828

S. Sokal, CHARTERED PATENT AGENT,
1, Great James Street, Bedford Row, London, W.C.1.
T.N. 4515 Museum. 8830

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 20 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidiatag, London."—Great Eastern Road, Stratford, E. 15. 1794

Machine and Engineering
WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, LTD., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9311

Locomotive Traversers
(ELECTRIC).
9026
S. H. HEYWOOD & CO., LTD.,
REDDISH.

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 8400

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
8880
See half-page Advertisement, page 90, Dec. 24.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 8443

The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the Interests of Foremen in their Supervisory Capacity. P 601

All communications to— H. W. REID, General Secretary. Head Offices— 95, Belgrave Road, Victoria, London, S.W.1.

Crystal Palace School of PRACTICAL ENGINEERING.

Principal: J. W. WILSON, M.I.C.E., M.I.Mech.E. Founded 1872.
The NEW COURSE will commence on WEDNESDAY, JANUARY 5th. L 320

The Sir John Cass Technical INSTITUTE.

JEWRY STREET, ALDGATE, E.C. 3.

DEPARTMENT OF METALLURGY.

A COURSE of TEN LECTURES, with associated laboratory work and practical demonstrations on THE MECHANICAL TESTING OF METALS AND ALLOYS, will be given by R. G. BATSON, A.M.Inst.C.E., M.I.Mech.E., on THURSDAY EVENINGS, from Seven to Ten p.m., commencing THURSDAY, JANUARY 13th, 1921.
FOUNDRY PRACTICE (Ferrous and non-Ferrous Metals) by GEO. PATCHIN, A.R.S.M., M.I.M.M. and A. F. GIBBS.
A course of 32 lectures and demonstrations accompanied by practical work in Moulding and Casting, Monday and Friday evenings, Seven to Ten p.m., commencing Monday, January 3rd, 1921.
Detailed Syllabus of the courses may be had upon application at the office of the Institute or by letter to the PRINCIPAL. L 324

Inst.C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "C" embraces 25 years' professional experience. Address, 7484, Offices of ENGINEERING.

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TEMVOR W. PHILLIPS, B.Sc.(Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8–10, Trafford Chambers, 58, South John Street, Liverpool. 8423

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.I.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 8070

Correspondence Tuition by

the "U.H.C." Individualised System will carry you through your Exam. with minimum expense and energy. Success Guaranteed. Established 1903. Hundreds of Successes at:—Stud.Inst.C.E., Assoc.M.Inst.C.E., A.M.I.Mech.E., A.M.I.E.E., Matriculation, Inter. and Final B.Sc. (Engineering), City and Guilds, Government Departmental Exams. etc. Specialised Professional Training.
APPROVED BY MINISTRY OF LABOUR.
Send for FREE "U.H.C." Prospectus No. 8, mentioning requirements to:—Desk "C."
UNIVERSITY ENGINEERING COLLEGE, Westgate-on-Sea, Kent. K 851

TENDERS.

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSALS BOARD
(PLANT AND MACHINERY SECTION).

For Sale by Public Tender.

ONE COMPLETE POWER STATION PLANT
Comprising:—
3—2000 K.w. Generating Sets
3,300 Volts, 3 Phase, 50 Periods
Complete with
Boilers
Pumps
Water Softener
and all Station Accessories.
TENDERS CLOSE ON FEBRUARY 1st.
For full particulars, Tender Forms, Permits to view, apply to:—
THE CONTROLLER, D.B.I.M., Charing Cross Embankment Buildings, London, W.C.2. L 329

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON—KING'S COLLEGE.

The Delegacy Require the

the SERVICES of an ASSISTANT LECTURER and DEMONSTRATOR in Civil and Mechanical Engineering. Salary £300 per annum. The duties will commence on January 12th, 1921. Opportunities will be given for research work.
Applications, with copies of not more than three testimonials, should be received not later than January 8th, 1921, by THE SECRETARY, of King's College, London, W.C. 2, from whom further particulars may be obtained. L 328

UNIVERSITY OF LONDON.

The Senate invite

Applications for the CHADWICK (part-time) CHAIR OF MUNICIPAL ENGINEERING

tenable at University College. Salary £400 a year. Applications (12 copies) must be received not later than first post on 1st Feb., 1921, by the ACADEMIC REGISTRAR, University of London, South Kensington, S.W.7, from whom further particulars may be obtained. L 79

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, SOUTH KENSINGTON, LONDON, S.W.7.

CHEMICAL ENGINEERING.

Applications are Invited for

the POST of LECTURER in Chemical Engineering. Salary £400 per annum. Applications, with three testimonials, should be sent in before Tuesday, 11th January, 1921, addressed to the SECRETARY. L 332

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

Applications are Invited for

the POST of LECTURER IN MECHANICAL AND ELECTRICAL ENGINEERING.
Salary according to scale; normal maximum £500, an additional £50 being payable in the case of candidates having a First-class Honours Degree or the equivalent.
In computing initial salary under the scale, full allowance will be made for years of service in teaching or in industry after 21 years of age.
Further particulars may be had from the PRINCIPAL, to whom applications should be sent before January 14th. L 317

Wanted, Works Manager

with knowledge of small car production and general engineering. Salary £300 to £350 to commence.—Address, L 304, Offices of ENGINEERING.

Qualified Surveyor Required

for Central Africa. Sound knowledge of Tachometric surveying and field work essential.—Write fully, stating particulars of training and experience, age, and salary expected, BOX A 88, LEE & NIGHTINGALE, Advert. Offices, Liverpool. L 315

Wanted, an Experienced

SURVEYOR for a firm of Consulting Engineers and Marine Surveyors in South Wales. Please apply, stating qualifications, age, and salary required. There are good prospects for a competent man.—Address, L 327, Offices of ENGINEERING.

Wanted, Experienced Cost

CLERK, for General Engineering Works, West London.—Address, giving full particulars, L 330, Offices of ENGINEERING.

Wanted, Motor Engineer for

small Midland Motor Works, capable of jig and tool designing and producing on up-to-date methods Motorcar Component Parts, and supervising complete car production. Salary £300 and bonus on production.—Address, L 283, Offices of ENGINEERING.

Applications are Invited

for APPOINTMENT of an OPTICAL ENGINEER as Assistant Manager, Mathematical Instrument Office, Survey of India, Calcutta. Applicants should be between the ages of 24 and 35, must have optical experience in a modern scientific Instrument-maker's factory, must thoroughly understand manufacture of Surveying Instruments and must be conversant with Machine shop practice and production. Engagement three to five years subject to renewal. Salary not less than 800 rupees per mensem, or more according to qualifications and experience.—Apply, REVENUE SECRETARY, India Office, London S.W.1. L 300

Wanted, for Bombay,

Thoroughly Competent and Experienced ENGINEER to represent old-established English Firm in conjunction with existing Agents. Special qualifications—practical knowledge of steam engines and mill-gearing for textile machinery. Three years' agreement with first class passage out and home.—Address, stating age, and salary required, with full particulars of experience, L 283, Offices of ENGINEERING.

Civil Engineers and

DRAUGHTSMAN REQUIRED by the GOVERNMENT OF NIGERIA for Railway Capital Works, for two tours each of twelve months' service, with possible extension. First-class passages and quarters provided. Liberal leave in England on full salary. As follows:—
Reference No. 10511. Appointment: District Engineers. Salary: £800–£40–£920 a year with proficiency pay of £72 a year. Qualifications: Good experience in responsible charge of Railway Surveys and Construction.
Reference No. 10512. Appointment: Assistant Engineers. Salary: £600 a year rising by annual increments of £30. Qualifications: Experience of Railway Surveys and Construction.
Reference No. 10517. Appointment: Draughtsman. Salary: £500–£12–£560 a year. Qualifications: Experience as Railway Draughtsman, capable of plotting plans and sections direct from field books, also experience of bridge and building design.
Candidates, not over 45 years of age, possessing the required experience, should apply at once, in writing, giving age and brief details of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting the reference number of the vacancy applied for.
Applicants must have served in some branch of H.M. Forces during the late War, unless satisfactory reasons for not having done so can be furnished. L 325

METROPOLITAN WATER BOARD.

ASSISTANT ENGINEER.

The Metropolitan Water Board are prepared to receive

Applications for the Appointment of an ASSISTANT ENGINEER.

Applicants must be Corporate Members of the Institution of Civil Engineers, from 30 to 45 years of age, and must have had experience in designing and setting out, and upon works of construction.
The successful candidate will be classified as one of the Senior Assistant Engineers. The appointment will be held during the pleasure of the Board at a commencing salary of £400 per annum, rising by annual increments of £25 to £500.
The foregoing salary is based on pre-war conditions and is subject to temporary additions, making the total minimum remuneration at present about £726 a year, rising to a maximum of about £880 a year. These amounts may, however, be increased or reduced according to fluctuations in the cost of living.
Applications, which must be accompanied by copies of not more than three testimonials, must be submitted on a form to be obtained from the Clerk of the Board, New River Head, 173, Rosebery Avenue, E.C. 1, and delivered to him at that address in a sealed envelope endorsed "Assistant Engineer" not later than Twelve o'clock noon on Saturday, the 22nd January, 1921.
The selected candidate will be required to pass a medical examination by the Board's Chief Medical Officer and to join the Board's Superannuation and Provident Fund.
Personal canvassing is strictly prohibited and will disqualify.

A. B. PILLING,
Clerk of the Board.

New River Head,
173, Rosebery Avenue,
London, E.C. 1.
22nd December, 1920. L 333

GREAT INDIAN PENINSULA RAILWAY.

The Directors are prepared to receive

Written Applications from

duly qualified candidates for TWO VACANT APPOINTMENTS as ASSISTANT ENGINEERS on the Company's staff in India.
Candidates, who may be between the ages of 24 and 30 years, must have received a sound general and technical education and have served an apprenticeship or pupilage to a Civil Engineer engaged in constructional work or to an Engineer to a British Railway Company.
Candidates must preferably have passed the Associate Membership Examination of the Institution of Civil Engineers, or have taken a degree exempting from such Examination.
The terms of the Appointment are a three years' agreement in the first instance which may be subsequently extended by arrangement. The salary for the first year will be Rs. 450 per mensem, for the second year Rs. 500 and for the third year Rs. 550. The Company will provide a first-class passage to India, and the salary will commence on the date of sailing for that country. Preference will be given to candidates who have had railway experience and who have served in the Army during the late War.
Applicants must give a full chronological record of their general and technical education, apprenticeship or pupilage and subsequent engineering experience, and must also state whether they are married or single.
Those who have served in the late War should give particulars of dates of that service.
Applications, accompanied by copies of any testimonials, must be addressed to the Company's Consulting Engineer, ROBERT WHITE, Esq., M.Inst.C.E., 3, Victoria Street, London, S.W. 1. L 323

COLOMBO MUNICIPAL COUNCIL, CEYLON.

WATERWORKS DEPARTMENT.

The Colombo Municipal Council requires the

Services of an Assistant

ENGINEER, who must have had a good technical education, and have been articled to a Civil Engineer and obtained experience on works of water supply, both in design and in the construction of new works and in ordinary maintenance.
Applicants should have passed the examination of Associate Member of the Institute of Civil Engineers or hold some other equivalent qualification.
Candidates should be unmarried and be between 25 to 32 years of age.
The appointment will, in the first instance, be a probationary one for a period of three years on an initial salary of Rs. 6750 per annum with an increase of Rs. 250 per annum after two years' service, and rising to Rs. 9000 per annum with a commuted allowance of Rs. 900 per annum. In addition there is at present a temporary allowance of 20 per cent. on the salary.
The selected candidate will be required to pass a medical examination.
The gentleman appointed will be required to enter into an agreement to serve the Council for a period of three years in the first instance, after which period, if his services are satisfactory, permanent employment under the Council, in accordance with its rules and regulations relating to leave, pension, etc., will be offered.
Free passages to Colombo, first class by non-mail steamer or second class by mail steamer, will be provided with half pay during the voyage out.
Should the services of the officer be not required at the expiration of the three years for any reason other than misconduct, or should the officer desire to terminate the appointment, free passage to England will be provided by the Council.
Applications endorsed "Assistant Engineer, Colombo," stating age and qualifications, and accompanied by copies only of testimonials, should be forwarded to:—

N. M. INGRAM, Esq.,
Burlingham Rectory,
Burlingham,
Norfolk,

and must be received not later than 15th January, 1921.

By Order,
E. H. JOSEPH,
Secretary, Municipal Council, Colombo.
The Town Hall,
Colombo, 13th November, 1920. L 194

Refrigerating Engineer.—

Thoroughly qualified MAN REQUIRED as Chief for large Stores in a Lancashire Port. Must have thorough practical knowledge of, and be able to control and supervise Refrigeration Plants (direct expansion and brine systems), Gas Engines and Producer Plants, Electric Power and Lighting Plants. Good commencing and progressive salary to competent man. Give full particulars of qualifications, experience, age, references and present salary.—Address, L 338, Offices of ENGINEERING.

First-class Draughtsman

REQUIRED for Commercial Motor Vehicle Works. Only thoroughly experienced men need apply.—State experience, age, and salary required.—Address, L 345, Offices of ENGINEERING.

Required, by Old Established

Engineering Firm in India, FIRST-CLASS STRUCTURAL DRAUGHTSMAN. Good salary and prospects for suitable man.—Reply fully, stating age, experience and salary required, and whether married or single, Z.F. 251, care of DEACON'S, Leadenhall St., London, E.C. 3. L 341

Chief Draughtsman Wanted

at once for well known firm of Steam Wagon makers. Applications will only be considered from those who have held similar positions. Excellent prospects for suitable man.—Address, L 265, Offices of ENGINEERING.

Draughtsman. — Required,

JUNIOR DRAUGHTSMAN and TRACER, used to dock machinery and general work.—Apply, stating fully experience, reference, age and wages required, to SMITH SLIPWAY COMPY., Erith, Kent. L 322

Draughtsman, Competent

Designer, preferably acquainted with Steel Ingot Casting Plant, REQUIRED temporarily, to prepare finished drawings. London District.—Address, L 337, Offices of ENGINEERING.

CITY AND GUILDS ENGINEERING COLLEGE.

DEPARTMENT OF ELECTRICAL ENGINEERING.

The Delegacy of the City and Guilds (Engineering) College invite

Applications for the Office

of ELECTRICAL DRAUGHTSMAN. Duties to give instruction in Drawing Office, and assist in Electric Traction Laboratory. Salary £350.
Applications, giving full particulars regarding age, education, training and experience, together with testimonials or references, should be addressed in the first instance, to Prof. T. MATHER, City and Guilds Engineering College, Exhibition Road, London. Ex-service man preferred. L 336

SURREY COUNTY COUNCIL.

COUNTY SURVEYOR'S DEPARTMENT.

Applications are Invited for

APPOINTMENT of FOREMAN OF WORKS, with experience in supervising large gangs of men and in excavation work.
Applications, in writing, stating details of experience age, and salary required, with references, should reach the undersigned not later than 8th January, 1921. Further particulars may be obtained from

W. P. ROBINSON, A.M.I.C.E.,
County Surveyor,
County Hall,
Kingston-on-Thames. L 313

Marine Shop Foreman for

Hong Kong, five years' engagement, age 30 to 40, well educated, energetic, thoroughly trained shop man, well up in modern tools, methods, and jobbing work, 2½ years 300 dollars, 2½ years 350 dollars per month, with quarters or allowance 70 dollars, second class passage, half pay. Applications till 30th January, giving age, experience, married or single, copies references, character, ability, sobriety imperative.—Address, CHINA, WM. PORTEOUS & CO., Advertising Agents, Glasgow. L 334

SITUATIONS WANTED.

Progress Manager Seeks

CHANGE. Records, Statistics, Stores, Stores Records, Sub-Contracts, &c. Good refs., distance no object.—Address, L 344, Offices of ENGINEERING.

Engineer (32) B.o.T., Extra

First-class Certificate. Secondary and Technical School education, DESIRES POST as assistant to Marine Superintendent Engineer, or similar occupation.—L 343, Offices of ENGINEERING.

Advertiser, 20 years' En-

gineering firms REQUIRES PERMANENCY. Certified Accountant, Accustomed costs, purchasing, selling, correspondence and secretarial.—Address, K 977, Offices of ENGINEERING.

Clerk with Seven Years' Ex-

PERIENCE in Engineering Costing and Estimating, REQUIRES POST.—Address, L 342, Offices of ENGINEERING.

Draughtsman (32) Desires

POST; used to works maintenance, design, lay out, erection, estimating for buildings, plans and furnaces in Chemical Works. Excellent testimonials.—Address, L 340, Offices of ENGINEERING.

Toolroom Foreman, 20 years'

experience. 6 years' supervision. Design and manufacture. Strict disciplinarian.—Address, Offices of ENGINEERING. L 340

THE THERMAL EQUILIBRIUM OF REFRIGERATING PLANTS.

BY EDGAR C. WEST.

IN designing a refrigerating plant one has usually certain definite data, such as temperature of cooling, temperature of condensing water, &c., from which the scantlings of the various organs may be derived. Under such circumstances the calculation is of a comparatively simple order which, therefore, does not present much difficulty. The problem, however, is not nearly so simple when it is required to predict the working temperature at which an existing plant will settle down when the temperature conditions are different from those for which the plant was originally designed.

The difficulty is centred about the temperature of evaporation in the refrigerating coils, for this variable is the one governing the compressor heat elimination more than any other. Condenser temperature has its effect upon compressor capacity, but to a minor degree when viewed in the light of the evaporation temperature.

Broadly speaking, there are two groups of variables, each group being dependent upon the other; a variation of one factor disturbs the whole balance, until a complete re-arrangement of the many factors causes equilibrium to be established again. On the one hand there is the evaporator surface through which heat is being urged by the temperature difference maintained by suction effect from the compressor. With constant surface, and with what may be regarded as a constant coefficient of transmission, the quantity of heat removed varies directly with the temperature difference. On the other hand, the compressor capacity for removing heat depends very largely upon the temperature at which the refrigerating medium enters the compressor; in the first place, this latter factor causes a change in the heat value per pound of stuff pumped and in the second place, a change of specific volume, which directly governs the weight of stuff dealt with by the compressor per unit of time. In addition to these there are numerous other factors influencing the compressor capacity, but these are best left aside for the present in order that the issue be not unduly complicated. We have then the two main points for consideration, the evaporator, with its variables, and the compressor, also with *its* variables. These two should be in exact working agreement, with the exception of the small leakage of heat into the connections and conduits coupling together these two organs, generally and properly speaking this leakage is very small.

It will be readily seen that a rise or fall in the evaporation temperature changes the capacity of the compressor for eliminating heat, the change also affects the ability of the evaporator to transmit heat to the refrigerant, but in the inverse ratio. For example, with compressor running at constant speed the inlet temperature of the substance being cooled, may rise, thereby increasing the temperature difference and causing more heat to be given to the refrigerant than the compressor can deal with without regulation. To make the compressor take up this extra heat the evaporation temperature must be elevated slightly, and this immediately reduces the temperature difference in the evaporator, so that a little less heat is transmitted, a final state of balance being eventually established by close adjustment of the regulating valve. The question the designer requires answering is, at what temperature will the plant settle down, so that thermal equilibrium is maintained?

No doubt there are many ways of answering the question, not the least used of which is that process of "hunting" so frequently employed in preliminary design work, of taking values above and below the point where one's experience suggests the actual temperature may be, and so by a little skilful manœuvring, arrive at a temperature not differing much from that which actual working may eventually prove it to be. The process is exceedingly useful, but even when used by experienced hands is somewhat long and tedious, but apart from this it certainly cannot be regarded as a scientific way of overcoming the difficulty. The following equation is therefore suggested as being sufficiently accurate for almost all practical purposes:

Let C = Compressor Capacity in cubic ft. per hour, net, = swept vol. × vol. eff.
k = Coeff. of Heat Transmission in B.Th.U. per hr. per deg. per sq. ft.
L_s = Heat taken up when 1 lb. of stuff boils under stated temperature conditions, neglecting the small terms $(S_1 - S_2) + \frac{1}{J}(p_1 - p_2)\,v_1$.
M = Surface area of cooling coils in evaporator, sq. ft.
T_1 = Mean temperature in deg. Fah. absol. of substance being cooled in evaporator.
T_2 = Temperature of evaporation of refrigerant in evaporation coils, deg. Fah. absol.
T_3 = Temperature of vapour discharged to condenser, deg. Fah.
Q = Heat in B.Th.U's, removed by evaporator per hour.
V = Volume of 1 lb. of refrigerant when dry and saturated at temp. T_2, cub. ft. per lb.

The capacity "C" must be increased by a suitable allowance for clearance re-expansion, valve drag and cylinder heating, in order to determine the actual cylinder sizes for any particular case.

The coefficient k must not be taken as the coefficient of conductivity as used in its physical sense, but is to represent the actual rate of heat transference as determined from tests upon a typical plant, under known conditions of the surfaces, temperature and velocity of flow, on the assumption that the thickness of the metal wall itself in various plants does not change sufficiently to render considerations of thickness necessary.

The mean temperature of the substances being cooled T_1 is to be taken in conjunction with the coefficient k, that is T_1 is to be reckoned on the same basis as that employed in the tests for k. If the arithmetic mean between the upper and lower limits of temperature has been used in the one then the same must be used in the other, should more exacting methods have been employed, as for example, the mean value found by integrating a cooling curve diagram, then this should be used, just as the case may be.

The latent heat L_s is the heat required to vaporise the major part of the liquid refrigerant present in one pound of stuff after it has passed the expansion value, but leaving sufficient wetness present to give complete saturation at the end of compression, thus $L_s = L_e \times \frac{\phi_3}{\phi_2}$, and this relationship, of course, neglects the small terms $(S_1 - S_2)$ and $v_1 (p_1 - p_2) \cdot \frac{1}{J}$, both of which are to the discredit of the apparatus. Every range of machines, and surely every different machine of a range has a value of the dryness fraction quite peculiar to itself, bound up with questions of hydraulic resistance, disposition of parts, and so forth, each case must be dealt with as circumstances and experience dictate. Then we have in the evaporator

$$Q = (T_1 - T_2)\,Mk \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

While in the compressor

$$Q = \frac{(C \times L_s)}{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

For correct thermal balance these two should be equal with the exception of the negligible loss mentioned above.

$$\text{Therefore } (T_1 - T_2)\,Mk = \frac{C \times L_s}{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

In order to deal with this equation it is necessary to express V as a function of T_2, and strictly speaking L_s should also be represented in terms of T_2, but usually its range is small enough for the value of L_s to be chosen without relating it to the temperature mathematically, the sole object being to bring about a very simple expression.

To express V as a function of T_2 appears most easily effected by plotting a temperature-volume curve for a particular refrigerant, and from that curve deducing an equation connecting the two variables, which will be sufficiently accurate over the range of working most usually found in cooling machines. The equation of state for most of the more generally used refrigerants, is unhappily, far too cumbersome for inserting in an expression which one wants to solve readily, while the gain in accuracy over the curve method, scarcely justifies the labour from a practical point of view.

$$\text{Let } V = \sqrt[y]{\frac{A}{T_2}} \text{ then } (T_1 - T_2)\,Mk = \frac{C \times L_s}{\sqrt[y]{\frac{A}{T_2}}} \quad . \quad (4)$$

neglecting the change in L_s as mentioned above.

This may be re-arranged into the form:—

$$(T_1 - T_2) = \frac{C \times L_s \times \sqrt[y]{T_2}}{Mk\sqrt[y]{A}} \quad . \quad . \quad . \quad . \quad (5)$$

Now for any particular plant working at constant speed we may take the fraction $\frac{C}{Mk\sqrt[y]{A}}$ as constant, thus neglecting changes in the volumetic efficiency, cylinder heating, coefficient of transmission, &c., which may be produced by changes in the working temperatures and specific weight of the refrigerant.

Therefore

$$(T_1 - T_2) = S \times L_s \times \sqrt[y]{T_2} \quad . \quad . \quad (6)$$

Take logs of each side:—

$$\log (T_1 - T_2) = \log S + \log L_s + \frac{1}{y} \log T_2$$

Let $(T_1 - T_2) = e^x$, then $T_2 = T_1 - e^x$

so that $\log e^x = \log S + \log L_s + \frac{1}{y} \cdot \log (T_1 - e^x)$

multiply each side by $\frac{1}{\sqrt[y]{T_1}}$, which is equivalent to subtracting $\frac{1}{y} \log T_1$ from each side:—

$$\log e^x - \frac{1}{y} \cdot \log T_1 = \log S + \log L_s + \frac{1}{y} \cdot \log \left(1 - \frac{e^x}{T_1}\right)$$

This step is introduced in order to cause the logarithmic series to converge very rapidly. Then

$$\frac{1}{y} \cdot \log \left(1 - \frac{e^x}{T_1}\right) = \frac{0{\cdot}4343}{y}$$
$$\left\{ - \frac{e^x}{T_1} - \frac{1}{2} \cdot \left(\frac{e^x}{T_1}\right)^2 - \frac{1}{3}\left(\frac{e^x}{T_1}\right)^3, \text{ \&c.} \right\}$$

For all practical purposes the first term only need be considered, for with ordinary conditions of temperature difference the second term only changes the logarithm in the fifth place of decimals.

Hence:—

$$\log e^x - \frac{1}{y} \cdot \log T_1 = \log S + \log L_s + \frac{0{\cdot}4343}{y} \cdot \left\{ - \frac{e^x}{T_1} \right\},$$

and

$$e^x = \left\{ 1 + x + \frac{x^2}{\lfloor 2} + \frac{x^3}{\lfloor 3} \cdot \ . \ . \ . \text{ \&c.} \right\},$$

which gives for the final equation

$$\frac{0{\cdot}4343}{T_1 \times y}\left(\frac{x^2}{2} + x + 1\right) + 0{\cdot}4343\,x - \frac{1}{y} \log T_1 = \log S + \log L_s \quad . \quad . \quad . \quad (7)$$

From this the value of x is readily obtained, so that e^x, or the temperature difference $(T_1 - T_2)$ is calculated with sufficient accuracy to meet all ordinary requirements, and as T_1 is known, T_2 is easily evaluated. The result is perhaps a little cumbersome for quick calculation, and this fact led the writer to prepare a chart embodying the various factors involved; the chart is necessarily of the alignment type, for it is one of the excellent properties of these charts that any number of variables may be plotted in proper relationship until the limit is reached when the chart becomes practically unmanageable.

For the preparation of this chart ammonia has been chosen as the working substance owing to its very extensive use in cooling plants in the past, and also in view of the possibilities of ammonia completely holding the field in the future.

THE ALIGNMENT CHART FOR AMMONIA COMPRESSION PLANTS USING "WET" COMPRESSION.

Upon referring to the chart it will be seen that only the factors governing evaporator and compressor performance are included. The condenser, equally important of course, for the efficient working of the plant, is more easily disposed of than the evaporator, and as the chart slowly grew in size it seemed advisable to limit its scope to the two organs chosen, leaving the condenser to be separately treated on its merits.

In all calculation relating to this chart the thermodynamic properties of ammonia have been taken from the tables of Messrs. Keyes and Brownlee,

compiled from the results of their investigations made at the Massachusetts Institute of Technology.

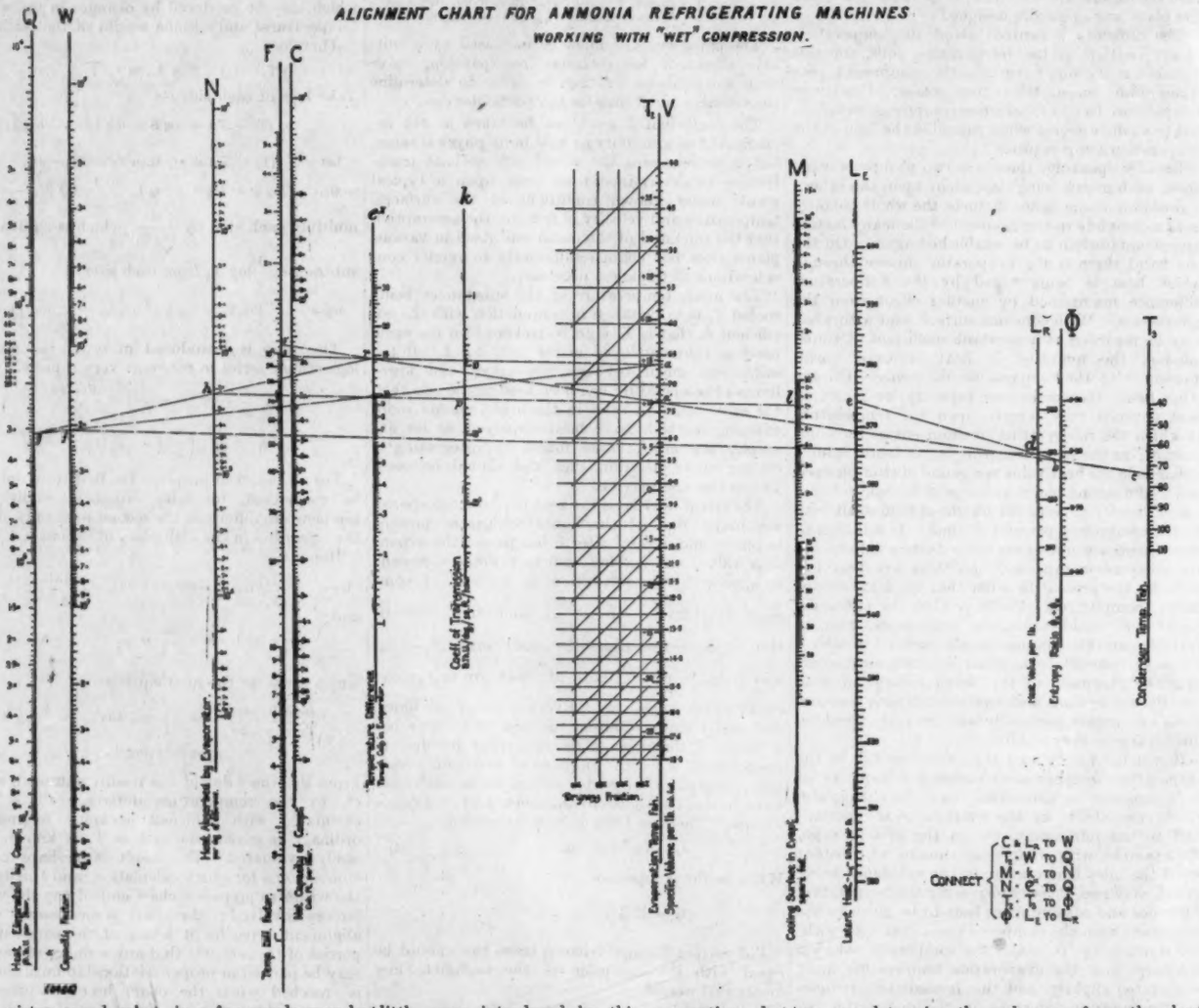
The relation between temperature and specific volume of the saturated vapour has been taken as

$$T_2 V^{0.1009} = 574{\cdot}19.$$

This relationship appears to hold fairly true over the range of temperature one usually finds in the operation of such plants, that is from − 10 deg. F. to + 40 deg. F.

The heat elimination is that which might safely be expected from a well-designed compressor having spherical covers and piston, with mushroom valves disposed with their centre lines as the generators of a conical surface, and working with but a moderate mean piston speed, what, in a few words may be styled a typical modern compressor.

ALIGNMENT CHART FOR AMMONIA REFRIGERATING MACHINES WORKING WITH "WET" COMPRESSION.



To Make Use of the Chart.

Case (1).—Given the heat elimination per hour, temperatures of cooling, temperature of condenser (as shown by ammonia gauge), what compressor capacity is required?

Fix upon an arbitrary temperature of evaporation some six or seven degrees below the final temperature of the substance being cooled, let it be + 10 deg. F. for the present argument, and accept + 75 deg. F. as a condenser gauge temperature compatible with the conditions obtaining, then with a straight edge or fine thread place a line from the point + 10 deg. on scale T_2 to point 75 deg. on scale T_1, and mark its point of intersection with scale Φ, say, as shown by a', b, c. Place a line from point b to the latent heat value on scale L_t, corresponding to the temperature of evaporation, and mark its intersection with scale L_t, say, line b, d, e. The point d gives the heat value per pound of little error introduced by this assumption; but with larger machines, where the piston speed is higher and the ratio of cylinder surface to cylinder volume improved it appears necessary to allow for the extra weight of vapour present in the cylinder just before the compression stage.

This point is provided for on the chart in the group of lines next to the scale T_2, these lines being merely an artifice for multiplying the specific volume by the dryness fraction, in order to obtain the correct volume per pound of stuff. It is seen at once that this method neglects the volume of liquid present in one pound of stuff, a quantity so small that it may reasonably be omitted.

To determine the corrected volume draw a line at 45 deg. from the intersection of the line from the evaporation temperature with the desired dryness fraction line, back to the volume scale, and read off there the reduced volume. This point a should then be used instead of the point a^1 first determined, for determining cylinder capacity.

Case II.—To determine the required cooling surface in the evaporator when the temperature difference $(T_1 - T_2)$ is known, and also the heat elimination Q. The designer will know from past experience what value of the heat transmission coefficient he may use for the particular type of evaporator it is proposed to install, then from the heat elimination value of scale Q place a line to the given temperature difference $(T_1 - T_2)$ on scale, let this line cut scale N at h, place a line from h through the transmission value p on scale k, and read off the surface required on scale M at point l.

It need hardly be mentioned that the inverse operations may be performed on the chart quite as readily; so long as we have sufficient known factors we can determine the unknowns from the chart, the two cases given being merely an indication of the methods to be pursued.

Case III.—Given the compressor capacity, the evaporator surface and the initial and final temperatures of the substance being cooled, also the condenser gauge temperature, find the temperature difference, the heat elimination and the temperature of evaporation.

This is the problem which gave rise to this article, it represents, of course, the case of an existing plant in which the working conditions are changed from those for which the plant was primarily intended.

Choose a value for the heat per pound approximating to that which one's experience suggests it may be, it cannot be found from the chart as described in Case I., because the temperature of evaporation is unknown. Place a line from this point on scale L_t, call it point d, through the compressor capacity on scale C, marking where the line cuts scale W; call this point f.

Place a line from the given evaporator surface on

scale M, through the heat transmission coefficient on scale k, and mark where it cuts the scale N, let this be point h. Next work out what has been called the temperature difference factor, that is:—$C \times L_a \div M \times k$, marking this value on scale F. Now take three strips of card or other straight-edges, place one with its edge against the point f, place a second piece with its edge on point h, and also over the point where straight-edge number one cuts scale Q, the other ends of these strips should now be working over the T_2 scale and the $(T_1 - T_2)$ scale respectively. Place the third strip at the point s on scale F, then manœuvre the strips so that the third straight edge contains the intersection of the strips one and two with the scales T_2 and $(T_1 - T_2)$, when the temperature difference and the evaporation temperature may be scaled off at points r and a say. Here again a correction to the temperature should be made by using the dryness fraction device in the inverse way. The heat elimination is then read off where the two strips meet the scale Q in a common point. Care must be taken when operating the strips so that the two always cross each other at a common point with the scale Q, as at point g.

On paper the method appears a little laborious, but once the diagram is mastered these processes may be carried out in a surprisingly short time, much quicker than by calculation, at the same time sufficient accuracy is observed for all practical purposes where the preliminary survey of a particular job is concerned. It must be remembered that the alignment chart is not expected at any time to give results to close limits, its value is bound up with quick computations on preliminary surveys; for final and more exacting solutions methods of calculation should be resorted to, with or without the guidance of an alignment chart.

Those readers who are conversant with the subject of refrigeration will have appreciated the advantages of choosing ammonia for plotting a chart such as the one described. Other mediums nearly as efficient in general use as ammonia from a thermodynamic point of view, could be treated similarly by suitable adjustments being made to accommodate the different physical characteristics of each individual case. Carbonic anhydride calls for rather more exacting treatment. Some of the assumptions made in this article, fully permissible in the case of ammonia, from the writer's standpoint, could not be tolerated where CO_2 is concerned. The basis of argument is general to all cases, but with carbonic acid additional terms must be introduced to provide a more refined analysis of the heat values, &c. Extensions could also be added to the diagram for power consumption, condenser surface, mean temperature difference in condenser, pounds of refrigerant pumped per unit of time, and many more, provided the working of the diagram be not discounted by added complication.

DEFECTS IN MOTOR VEHICLES AND THEIR REMEDY.

By F. STRICKLAND.

(*Concluded from page* 798.)

Universal Joints.—Three main types of universal joints were employed in the motor vehicles: (1) The pin joint, (2) the sliding block joint, (3) the leather joint. None of these proved to be perfectly satisfactory, though all could be made to work very well if really properly made, and if the general design of the vehicle was suitable.

In considering universal joints it must be remembered that they are situated under the vehicles, and are therefore not at all convenient to lubricate. Where the engine and gear box form one unit and the propeller shaft is enclosed in a torque tube, as is the case in many of the light cars, there is only one joint, and this works at a small angle and is enclosed in the ball joint at the front end of the torque tube. It is therefore well protected from dust and can generally be arranged so that it is easily lubricated by oil thrown out from the gear-box, or alternatively a lubricator can be fixed which is easy to get at through the floor boards. In the case of cars and lorries with unenclosed propeller shafts and gear boxes separate from the engines, the joints are exposed to the dust, and some of them are frequently very inconvenient to get at. It is usual to encase them in a leather cover which has to be unlaced to lubricate them, and to do this the driver has to get underneath the vehicle. Consequently lubrication is often neglected. In the case of the heavy lorries where the propeller shaft is enclosed in a torque tube it is not usual for the latter to go right up to the gear-box, and there is therefore an unenclosed joint behind the gear-box. The pin joint is therefore not very satisfactory, as the oil is thrown out of the wearing parts by the centrifugal force.

In some cases in the lorries pin joints were provided with ball bearings, and these avoid the lubrication difficulty. In practice these worked extremely well and gave very little trouble, the only objection to them being that they are more expensive and also slightly heavier.

The pin joint does not provide for any longitudinal motion and therefore it is usual to fit one of the joints to the shaft by a splined joint. The lubrication of this is apt to be neglected and in some cases it wore considerably, in which case both the body of the joint and also the shaft had to be scraped. The sliding block type worked very satisfactorily if really well made and well looked after, but if neglected was liable to wear and rattle. The leather joint worked excellently if the lay-out was such that it did not work at any great angle. It was perfectly successful when used between the engine and gear-box where it ran theoretically in a straight line. It was also perfectly successful in one particular make of lorry between the gear-box and the back axle, this lorry having a very long propeller shaft and being so designed that the joints run straight under normal load.

In other types of lorry where the joint normally worked at a considerable angle the leather joint gave a great deal of trouble and was given up. Where the general design of the chassis is suitable the leather joint seems the best to use, as it has the great advantage of requiring no lubrication or other attention.

Lubrication.—A point in motor vehicles which requires a great deal of consideration is the matter of lubrication. It is usual to lubricate the engine by some means which employs a tank or sump carrying enough oil for a considerable run. The gear-box and back axle are lubricated by filling them to a certain level with oil and allowing the gear wheels to pick this up and distribute it. The various small parts, such as shackle pins, are generally fitted with small grease cups. Where the wheel bearings are of the plain type grease is generally used and is supplied by unscrewing the hub cap and filling it with grease and then screwing it on again when the grease is forced along the bearing.

In many cases these methods are open to a good deal of improvement. It we take the average 3-ton lorry we find that to lubricate every part thoroughly takes a very considerable amount of time every day. Under the conditions prevailing in a great part of the war there was little difficulty in this because the number of hours actually worked by the vehicles was very small, and the men had ample time to look after them during the rest of the day. There were, however, times when the lorries were worked long hours, and in this case it was often quite impossible to get the detail lubrication attended to, with the result that there was considerable wear on the small parts.

In commercial life there is no difficulty in arranging for the lubrication to be attended to however inconvenient it is, but on the other hand it costs money. If one vehicle requires an hour spent on it every day while another only needs half this time, the saving of cost on the latter in a year will be very perceptible. Further, this lubrication has often to be done out of working hours, when men are paid overtime rates and its superintendence is not always easy. In the case of small concerns where the driver does his own lubrication the time spent is practically a reduction of the working hours on the road, and, it follows, of the carrying capacity of the vehicle. Every effort ought therefore to be made to reduce the amount of lubrication required and to make it as convenient as possible to do. Thus the filling plug on the engine should be really convenient to get at and the oil gauge or level cock easy to see while the sump is being filled. If an oil-level cock is used it should have the handle really accessible. The same remarks apply to a large extent to the gear-box and back axle, though these do not as a rule require filling up as often as the engine.

The greater part of the time spent in lubricating is, however, spent filling up the innumerable small greasers for such parts as spring shackles, brake, camshafts, &c. There is no doubt that the present means of lubricating these are very unsatisfactory. The greasers are small, and if the parts are to be properly lubricated have to be refilled nearly every day. The tops frequently come off and get lost on the road; in fact the loss of greaser caps was so great in France that it was found desirable to tie the caps to the chassis with a short length of chain. Where there are some two dozen such greasers on a chassis the time taken to fill them all is very considerable, and even then the grease does not always get where it is wanted.

The first thing to be done is to reduce the number of parts requiring lubrication to a minimum, and a consideration of the number of wearing parts in different arrangements of back axle suspension, &c., will show that something can be done in this direction. The next point is to consider whether more convenient means cannot be devised. Oil-less bushes are being tried, and may solve many difficulties. Alternatively it would probably be possible to devise oil cups for the various parts which could be filled in a very small fraction of the time now taken to fill the grease cups.

Weight.—A most important point in the cost of upkeep of vehicles is the question of weight. Roughly speaking, the cost of running a vehicle will be proportionate to the weight to be moved, and therefore if a vehicle is made lighter it will require less petrol, oil, &c., and will wear the tyres less. If the weight is reduced there will also be less load on practically all the wearing parts, and therefore either these will wear longer or can be made smaller, and therefore cheaper.

It is not possible here to go into the various means by which weight can be economised. It may, however, be pointed out that in the very large majority of vehicles there is a margin for reduction of weight, and in some cases a very large one. In considering this matter it must of course be remembered that expensive forms of construction such as are used in aeroplane work, are generally inadmissible on account of limitations of selling price. Weight can, however, be saved in many cases without any increase in cost at all. The first point is that to get the lightest engine per actual maintained horse-power we must use a moderate speed engine. This has been conclusively proved by aeroplane engine practice. The extreme high-speed engine used on many of the fashionable cars is very heavy and is one of the reasons for the modern car having gone up in weight so much.

The next point is that such parts as the engine and gear-box should be as compact as possible in proportion to the size of the working parts contained in them. Careful design would in many cases reduce the size of the cases without in any way reducing the size of the essential parts, and would thus effect a considerable saving in weight. Castings should give way where possible to stampings or sheet steel pressings. Live back axles of lorries are a case in point. Every part should be carefully designed with the least metal for the strength required. One carrying company succeeded in reducing the weight of a standard lorry chassis quite considerably by coring out all the useless metal in such parts as spring brackets, &c., without in any way reducing the strength.

General Conclusions.—From what has been said it can be seen that although the motor vehicle, whether lorry or pleasure car, is a very satisfactory machine, there is still room for a good deal of improvement. This is not likely to take the form of any radical change, at all events for some time, but will be in the nature of continuous improvement in detail. The locomotive of to-day is in general outline very much like that of seventy years ago, but is distinctly more durable and economical in every way through improvement in detail, and the motor vehicle will probably go through a similar pro-

cess. Such items as petrol and tyre costs are largely a matter of weight, and though it is of course possible that there may be improvement in such items as carburators, &c., we must look mainly to weight reduction for better results. A considerable portion of the cost of upkeep of motor vehicles is, however, in the general garage expenses, such as lubricating, repairs and replacements, and there is no doubt that here there is a very large margin indeed for improvement.

The experience of the war has shown that many parts of the various vehicles are not by any means so durable as they might be made, and are often unnecessarily expensive to replace; further, that there were a great many breakages of parts which should not give trouble in this way. Different makes of vehicle varied in the different parts which gave trouble, some being better in one part, some in another, but it can hardly be said that any make did not show some very striking defects in these respects. This is, of course, natural, considering the short time the motor vehicle has been in general use, and it reflects great credit on the motor industry that the vehicles have reached the standard they have.

Now that the war is over, however, the various firms will need to go through their designs very carefully in order to reduce the cost of upkeep to the very lowest point consistent with the fulfilling of the various other requirements. They should at the same time scrutinise very carefully their designs in order to see to what extent they can reduce the time required to lubricate the vehicles and generally keep them in order. It appears safe to say that in many cases a really careful consideration of each item, both in the matter of time spent in lubrication and attention, and also in the matter of spare parts and replacements, would reduce these costs by quite half that involved with the chassis used in the war. There can be no doubt that our firms will have to face very serious competition by the American and probably also the Continental makers both in the overseas markets and also in the home market, and the points above mentioned will sooner or later tell very heavily.

WELLS AND THE PERMEABILITY OF SOILS.

All soils and rocks are permeable, even flint and agate show signs of the passage of water through them; the terms permeable strata and impermeable strata indicate only the degree of permeability of the strata. The flow of water through a saturated porous medium, such as soil, sand, small gravel, and through the pore spaces of rocks, not through fissures, is effected through the small irregular pipes formed by the pore spaces in the medium; the flow may, therefore, be regarded as capillary, which is essentially the flow of water through pipes of small internal diameter at velocities which are less than the "critical velocity." This velocity of flow is given by the equation—

$$v = c\,d^2\,\frac{h}{l} \times \frac{1}{w} \quad \text{(Poisseniles' experiment).}$$

Where c is a constant.

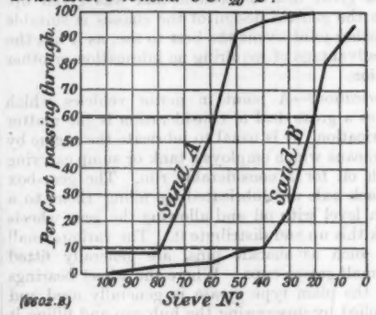
d = diameter of the pipe or tube
h = pressure head
l = length of pipe
w is a coefficient of viscosity depending on the temperature of the water.

In a porous medium d and l cannot be measured, but they bear a certain ratio to the length of the medium traversed by the water, and the diameter of the minute particles or grains forming the medium. We may, therefore, consider that the flow of water through a saturated porous medium depends on the squares of the diameters of the grains forming the medium, assuming these grains to be spheres. Ordinary sand has grains averaging in size from 0·3 mm. to 0·4 mm. Fine blown sand has size of grain varying from 0·15 mm. to 0·2 mm. The size of grains of a water-bearing sandstone may average 0·15 mm. An argillaceous soil may have size of grain varying from 0·002 mm. to 0·032 mm. Very fine silt may have size of grain ranging from 0·001 mm. to 0·003 mm. Consequently, the flow of water through the sands and sandstone will be many thousand times greater than the flow of water through the argillaceous soil, and fine silt; that is if the porosity of the various materials were the same. Hence we call the sands and sandstone permeable, and the clay soils impermeable. The flow of water through the saturated medium depends also on the pore spaces per unit of the medium or on its porosity. The greater the porosity the greater the flow. If the grains forming the medium were all of a uniform size, the porosity would vary between 25·95 per cent. and 47·64 per cent., according as the grains are arranged, as (*a*) or as (*b*) *vide* in Fig. 2 subjoined. If the water contained in soil or sand exceeds that required for complete saturation, the soil loses its stability, becomes light and has a tendency to flow. Colonel Clibborn (Technical Paper No. 99, Government of India Irrigation Department) states that from observations made on the change in the conditions of large horizontal surfaces of sand under varying heads of pressure, it was found that the texture of the mass of sand became light and porous to a marked degree under high heads, so that a heavy substance placed on the sand would sink some distance, and also the sand flowed readily with the gentlest horizontal current. This phenomenon is often observed in the dry sandy beds of Indian rivers, after the rains. In places where the sub-soil flow is forced

Fig. 1. *Per Cent of Voids.*
(a) Porosity 25·95%. (b) Porosity 47·64%. (c) Porosity less than 25·95%.

(6602.A.)

Fig. 2. SAND ANALYSIS.
Sand A. Finer 10% Sieve No. 61. Finer 60% Sieve No. 62. E.S.-0·22 m.m. UC-4/1-1·31.
Sand B. Finer 10% Sieve No. 40. Finer 60% Sieve No. 20. E.S.-0·46 m.m. UC-2/1-2.



(6602.B.)

to the surface, the sand loses its stability, so much so that horse and rider often flounder in what appears to be a quicksand, but which is in reality a slowly moving stream of what may be called super-saturated sand. Soil with over 50 per cent. voids and fully saturated so that every space within the soil is filled with water is unstable, and under pressure will act as a liquid.

In "recent" geological formations generally, no other sources for a water supply will be considered than beds of sand or similar material. Beds of gravel are comparatively rare, and in the very great majority of cases a bed of sand is the source of supply. In the graphic analysis of a sample of sand taken from a bed of saturated sand, which it is proposed to be used as a source of water supply, the total per cent. by weight of the sample passing through a sieve of a certain gauge is represented as an ordinate to the size of grain as abscissa, a coarse sand is indicated by a large abscissa compared to the ordinate, and a fine sand by a large ordinate compared to the abscissa. It is usual to grade the sand by a series of sieves of a certain number of meshes to the linear inch. The table in the next column shows the relation between the sieve number, or number of meshes to the inch, to the corresponding diameter of the sand grains in millimetres. That is the width of the sand grain and not its length is assumed as the diameter.

Mr. Allen Hazen* classes different sands by what he terms the effective size of the samples. The effective size, or E.S., of a sample of sand is such that 10 per cent. by weight of the material is of smaller grains and 90 per cent. of larger grain than the size given. His reason for such classification is that in a mixed material containing particles of various sizes, the water is forced to go round the larger particles, and through the finer

Sieve No.	Size of Grain in Millimetres.	Sieve No.	Size of Grain in Millimetres.
140	0·135	40	0·46
120	0·155	30	0·71
100	0·18	20	0·96
90	0·20	18	1·10
80	0·22	14	1·52
70	0·24	10	2·04
60	0·32	6	3·90
50	0·39		

portions which occupy the intervening spaces, and so it is this finest portion which mainly determines the frictional resistance, the capillary attraction, and, in fact, the action of the sand in almost every way.

The uniformity coefficient of a sample of sand is the ratio between the sieve number separating the coarser 90 per cent. from the finer 10 per cent., and the sieve number separating the finer 60 per cent. from the coarser 40 per cent. If the grains of sand were all of one uniform size, the uniformity coefficient would be unity, and the porosity of such a sand *in situ* would vary as stated above between 25·95 per cent. and 47·64 per cent. If smaller grains are introduced by suitable gradings the percentage of voids can be considerably reduced (*vide c*, Fig. 2), and the uniformity coefficient would be increased. The uniformity coefficient may, therefore, be considered an indication of the ratio between the sizes of the larger and smaller grains; and is in a measure an indication of the porosity. In a good water-bearing stratum of sand the effective size lies between sieve No. 30 and sieve No. 60. The uniformity coefficient should not generally exceed 3.

The following are examples of sand analyses, *vide* Fig. 2:—

Sand A.—Sample of sand taken from a stratum of fine sand struck by an experimental well. The yield from the stratum was small, and the sand was easily "blown" into the well at a moderate pumping head.

Passed through a No. 20 Sieve 100 per cent.
Passed through a No. 30 sieve 98 per cent.
Passed through a No. 40 sieve 96 per cent.
Passed through a No. 50 sieve 92 per cent.
Passed through a No. 60 sieve 52 per cent.
Passed through a No. 80 sieve 8 per cent.
Passed through a No. 100 sieve 8 per cent.
Effective size, 0·22 mm.
Uniformity coefficient, 1·31.

Sand B.—A coarse layer of sand struck below sand A, yielded a more copious supply, and was not easily "blown" into the well.

Passed through a No. 6 sieve 96 per cent.
Passed through a No. 10 sieve 88 per cent.
Passed through a No. 16 sieve 80 per cent.
Passed through a No. 20 sieve 60 per cent.
Passed through a No. 30 sieve 34 per cent.
Passed through a No. 40 sieve 10 per cent.
Passed through a No. 50 sieve 8 per cent.
Passed through a No. 60 sieve 4 per cent.
Passed through a No. 80 sieve 3 per cent.
Passed through a No. 100 sieve nil.
Effective size, 0·46 mm.
Uniformity coefficient, 2.

As already stated in the early part of this article, the flow of water through a porous medium depends on the diameter of the soil grains forming the medium, the length of the medium traversed by the water, the head or pressure producing flow, the porosity of the medium, and the viscosity which varies inversely as the temperature. If q = the rate of flow—

$$q = C\,\frac{h}{l}\,A\,\frac{d^2}{w\,p}$$

When c is a constant,

h = difference of pressure at the ends of and just inside a cylinder of the material of length l.
A = area of the cross-section of the cylinder.
d = effective diameter of grain in mm.
p = a coefficient depending on the porosity.
w = a coefficient depending on temperature of the ground water. Values of p for various per cent. of porosity and values of w for various temperatures in degrees centigrade are given in the following tables.

* Report of the Massachusetts State Board of Health, 1892.

Porosity Per Cent.	Value of p.	Porosity Per Cent.	Value of p.	Porosity Per Cent.	Value of p.	Porosity Per Cent.	Value of p.
26	84·29	32	41·76	38	24·09	44	14·75
27	74·05	33	38·63	39	22·11	45	13·71
28	65·93	34	34·75	40	20·30	46	12·75
29	58·90	35	31·55	41	18·73	47	11·82
30	52·48	36	28·79	42	17·27		
31	47·12	37	26·26	43	15·96		

It will be seen that porosity of the stratum, and temperature of the ground water have a marked effect on the flow.

μ Coefficient of Viscosity for Temperature t Deg. C.

t	μ	t	μ	t	μ	t	μ_1
0	0·0178	6	0·0147	12	0·0124	18	0·0106
1	0·0172	7	0·0143	13	0·0120	19	0·0103
2	0·0166	8	0·0138	14	0·0117	20	0·0101
3	0·0161	9	0·0135	15	0·0114		
4	0·0156	10	0·0131	16	0·0111		
5	0·0152	11	0·0128	17	0·0109		

The values for p and w are those ascribed by Professor Charles Slichter (19th Annual Report, U.S. Geological Survey, 1897–98).

$$\text{If } M = C\frac{d^2}{w\,p}$$

$$q = M\,A\,\frac{h}{l}$$

If A h and l are unity, M is the quantity of water that would be transmitted in a unit of time through a cylinder of the porous medium one unit in length, one unit cross sectional area and under one unit head or difference of pressure at the ends of and just inside the cylinder. M may be called the "modulus" of the medium. The law fails to hold good for high pressures as probably capillary flow is destroyed. The law fails to hold good for beds of coarse gravel exceeding about 3 mm. in effective size. Mr. Allen Hazen states that in such gravel beds the velocity varies as the square root of the head, and not directly as the head, and the velocity with a given head does not increase as rapidly as the square of the effective size. The influence of temperature is also less marked. Colonel Clibborn (Technical Paper 97) in experiments with a pipe 100 ft. long and 2·5 sq. ft. sectional area, packed with sand found that from heads varying from 1 ft. to 19ft. the discharge curve was practically a straight line. He obtained the values of M in cubic feet per 24 hours for the following Punjab sands (comparatively fine sands) where the units were 1 ft. length of cylinder, 1 ft. head of water, and 1 sq. ft. sectional area.

Khanti Sand.—Angle of repose 33° 3′. Specific gravity 2·652. Per cent. of insoluble matter after sulphuric acid treatment, 90·8. Per cent. removed by mechanical analysis, 42·3. M = 30.

Jamro Sand.—Angle of repose 33° 88′. Specific gravity, 2·704. Per cent. of insoluble matter, 88·8. Per cent. removed by mechanical analysis, 83·1. M = 42.

Temperature 67 deg. F. to 74 deg. F.

Mr. Beresford, in the same paper, states that M varied from 24 cub. ft. to 70 cub. ft. per 24 hours according as the sand was tightly packed, porosity about 0·17; or loosely packed, porosity about 0·5.

Mr. Allen Hazen's formula to determine the flow of water through sand or other soils gives the value of M, the same units of 1 ft. being used, as

$$M = 3{\cdot}28\,C\,d^2\,\frac{t+10}{60}$$

Where

M is the flow in cubic feet per 24 hours.
d is the effective size of grain in mm.
c is a coefficient generally taken as 1,000, but which varies according to the condition of the sand whether clean or dirty, and is influenced by the uniformity coefficient.
t is the temperature of the ground water in deg. F.

On page 302, vol. xlviii, Transactions, American Society Civil Engineers, are given the results of experiments showing the influence of a small quantity of clayey or dirty matter in causing a diminution of flow through the sand. Messrs. Slichter ("Motion of Underground Waters," Water Supply and Irrigation Papers, United States Geological Survey, No. 69) and Baldwin Wiseman (Proceedings, Institution Civil Engineers, vol. clxxi, 1910, page 39) give formulæ for the flow of ground water. These formulæ may be more accurate in small scale experiments, but involve laborious work in determining coefficients. As in actual practice porosity, surface area per unit volume, and other qualities vary from point to point, Hazen's formula appears to be sufficiently accurate to be used for preliminary calculations, if samples of this water bearing stratum can be obtained. M, however, is best determined by actual yield tests of wells sunk into the water-bearing stratum under investigation.

4. The flow of ground water is exceedingly slow. Colonel Clibborn estimates that in the Ganjuli alluvium, composed of beds of sand, clay and loam, extending to a considerable depth, the slope of the ground water plane is about 1 in 250; and the velocity of a solid column of water of the same area as that through which percolation occurs is about one mile a year. Observations made by American and French engineers arrive at similar velocities. Experiments at Rohlfeist for a period of seven years show the velocity of ground water flow in coarse sand, glacier and river drift to be from 1·64 ft. to 13·12 ft. per day; in gravel from 16·4 ft. to 328 ft. per day.

The following figures are due to Professor Nazzani, of Rome* :—

Values of M in cubic feet in 24 hours—
Small gravel ... M = 2,075 ft., size about 2 mm
Coarse sand ... M = 224 ft., size about 2 mm.
Fine sand ... M = 40 ft., size about 0·2 mm.
Sandy soil ... M = 19 ft.,
Sandy clay ... M = 10 ft.
Clay ... ... M = 2·8 ft.

GOODS AT OWNER'S RISK.

THE high freights which are now demanded by railway companies in consequence of greatly increased working expenses naturally tend to tempt the trader to avail himself of the privilege of sending his goods at "owner's risk." By so doing, he may save a considerable sum in cost of carriage; but, of course, his goods are exposed to certain dangers from which, if he is content to pay their ordinary rates, the railway company, as carriers, are bound to insure him. Many people, however, consign goods at "owner's risk" without realising at all, or, at any rate, without fully realising what it involves. And it is of particular importance to understand what it means at the present time in view of the fact that losses in transit have recently assumed very formidable proportions.

A recent case in the Court of Appeal has served to draw attention to the legal position of the trader who has consigned goods at "owner's risk"; but in order to understand that case it may be useful to say a few words on the subject generally.

In respect of all goods of which they are common carriers—and these comprise the largest proportion of goods carried by rail—the companies are insurers. They are liable in respect of every loss or injury unless occasioned by the Act of God or the king's enemies. But a company need not assume the *rôle* of a common carrier—it may give notice that it will not be a common carrier of particular goods. A railway company is also bound by statute to afford reasonable facilities for receiving, forwarding and delivering practically *all* goods, and in discharging these duties the company are liable for the negligence of their servants which causes loss of or injury to goods carried by them, unless the consignor has signed a contract by which he relieves the company from liability. The terms of that contract must, however, be just and reasonable.

Matters are generally adjusted in this way. The company accepts goods either upon the terms of an ordinary consignment note—in which case their liability is that of common carriers—or else they accept them subject to the consignor signing an "owner's risk" consignment note. Goods consigned at "owner's risk" are carried at a lower rate. The form of note in common use excuses the company from all liability "for loss, damage, misdelivery, delay, or detention" except upon proof that it was caused by the wilful misconduct of the company's servants. But the agreement does not exempt the company from any liability in the following cases of non-delivery, pilferage, or misdelivery (that is to say): (1) Non-delivery of any package or consignment fully and properly addressed, unless such non-delivery is due to accidents to trains or fire; (2) pilferage from packages or goods protected otherwise than by paper or other packing readily removable by hand, provided the pilferage is pointed out to a servant of the company on or before delivery; (3) misdelivery, where goods fully and properly addressed are not tendered to the consignee within 28 days after despatch. Provided that the company shall not be liable in the said cases of non-delivery, pilferage or misdelivery on proof that the same has not been caused by negligence or misconduct on the part of the company or their servants. It follows that if goods, properly addressed, are sent at "owner's risk," and are not destroyed in a train accident or by fire, the company are liable unless they can prove their servants to have been guilty of no negligence or misconduct. On the other hand, if goods are despatched insufficiently addressed, and fail to come to hand, the consignee would have to prove wilful misconduct on the part of their servants in order to make the company liable.

It thus appears that one who sends goods at "owner's risk" may have to undertake the very heavy burden of showing that the company's servants were guilty of wilful misconduct. This is something far beyond ordinary negligence. In *Norris v. Great Central Railway* 114 L.T. 183 two judges of the King's Bench Division approved the following definition. "Wilful misconduct is misconduct to which the will is a party as contra-distinguished from accident, and is far beyond any negligence even gross or culpable negligence, and involves that a person wilfully misconducts himself who knows and appreciates that it is wrong conduct on his part in the existing circumstances to do or to fail or omit to do (as the case may be) a particular thing and yet intentionally does or fails or omits to do it or persists in the act, failure, or omission regardless of consequences, or acts with reckless indifference as to what the results might be."

In the case above referred to (*Smith v. Great Western Railway*) the question at issue was the liability of the company for the total loss of certain packages of tools. A parcel of tools was despatched from Birmingham to Wilton, but was not delivered at its destination. The railway company were unable to explain what had become of them. A county court judge held that on the evidence before him the loss of the parcel was caused by the wilful misconduct of the company's servants on the ground that the disappearance of the parcel without explanation was tantamount to wilful misconduct. Two judges of the King's Bench Division held on appeal that the onus of proof of wilful misconduct by the company's servants rested upon the claimants and that no such proof was forthcoming. The parcel might have been lost by misadventure, wrong delivery or the wilful misconduct of a member of the public. On appeal to the Court of Appeal, this decision was affirmed by a majority of the Court.

It follows from this decision that it is not sufficient for a consignor to prove the mere fact that the goods which he sent have not arrived. If, in such a case, the company are able to show there was no wilful misconduct they are discharged from liability.

INTERFEROMETER FOR TESTING OPTICAL SYSTEMS.

To the optical instrument maker non-spherical surfaces offer, in some cases, certain advantages over spherical surfaces. Spherical mirrors and lenses do not bring marginal rays to the same focus as axial rays: parabolical and hyperbolical surfaces are not subject to this spherical aberration, but the accurate production of non-spherical surfaces is a difficult operation. Spectacle lenses with definitely aspherical surfaces were introduced by the Zeiss works about ten years ago, but perfect aspherical lenses for telescopes and cameras are hardly yet commercial articles. The lens or lens-combination has hence to be given the required correction in the same way as it is corrected for other defects, and this correction is largely based on the observation of some interference bands, the interpretation of which is not an easy matter. The interferometer of Messrs. A. Hilger, Limited, which was

* Irrigation Pocket Book, R. B. Buckly, C.S.I.

developed by Mr. F. Twyman assisted by Mr. Alfred Green and other members of the staff of the firm during the war, differs from these devices by furnishing the optician, not with a system of bands, from which he has to calculate his corrections, but with a contour of the irregularities of his surface, showing him directly where his lens or prism has to be corrected and enabling him to secure definite departures from sphericity. We illustrate this interferometer and some photographs exemplifying its use on the present and opposite pages.

In its simplest form the instrument resembles the Michelson interferometer, but differs from it optically in that the two interfering beams are brought to a focus at the eye of the observer. Our diagram, Fig. 1, explains the principle of the instrument when used for prism testing, the specimen being a prism of 60 deg. Fig. 2 is a view of the same instrument when fitted up for lens testing; a further modification of the instrument is required for the testing of camera lenses. All the parts are movably mounted on a strong table of

Fig. 1.

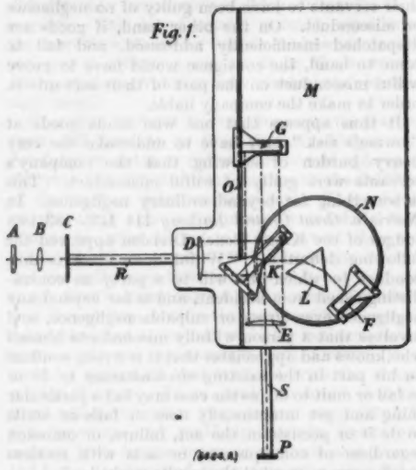
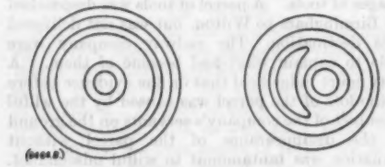


Fig. 3.

Fig. 4.



cast iron, and are readily accessible; there is no need for any casing. The source of monochromatic light used is a quartz-mercury lamp. The beam is reflected from the lamp by the adjustable mirror A (Fig. 1) through the condensing lens B on to the aperture of the diaphragm C and the diverging pencil of rays is collimated by the lens D to fall on the plane-parallel glass plate K standing on the table. The back surface of this plate is lightly silvered so as to reflect most of the light, but to transmit part of it. The transmitted beam goes on to the prism L, which is under test, and passes through it on to the plane mirror F which reflects it back along the same path, that is, through the prism again and on to K. The part originally reflected by K has meanwhile travelled up to the mirror G and back to K. Here the two beams recombine and proceeding through the lens E each of the beams forms on the eye placed in front of the diaphragm P an image of the hole in the diaphragm C. Any inequalities in the optical surfaces of the prism, by retarding some of the light waves irregularly in comparison with those travelling along the path G K in air only, will produce interference and the interference bands seen form a contour map of the surfaces marked out in wave-lengths. This map indicates which portions of glass have to be removed to render the surface optically perfect.

In the lens interferometer (Fig. 2) T is the lens under examination and U is a convex mirror which is placed like the plane-mirror F in Fig. 1 in order to reflect the rays which have passed through the lens T back along their own path. The other parts are as in Fig. 1, but the convex mirror U can be moved and its distance from T altered by turning the handle V of a screw on which U is mounted. A plane wave front falling on a prism leaves the prism with the front still plane, but a plane wave front falling on a lens leaves the lens with a spherical front. In Fig. 2 the rays from K fall normally on T and—supposing everything to be perfect—the spherical wave front leaving T should, by the combination TU, if properly adjusted, come back to K as a plane wave front. If either the lens or the adjustment be not perfect, interference bands will be seen forming a contour map of the wave front. The photographs to be described later show what is actually seen and the diagrams Figs. 3 and 4 will help to explain how the contour lines arise. In Fig. 3 we see a number of rings indicating that there are hills and valleys on the lens surrounding a central spot; Fig. 4 looks entirely different, but really represents the same case, the distortion having been produced by simply pressing with the hand on the iron table of the instrument. The pressure tilts the mirror F so that the path of the beam FK is lengthened; a slight adjustment of the mirror G would have the same effect. The optician may work with whichever plane of

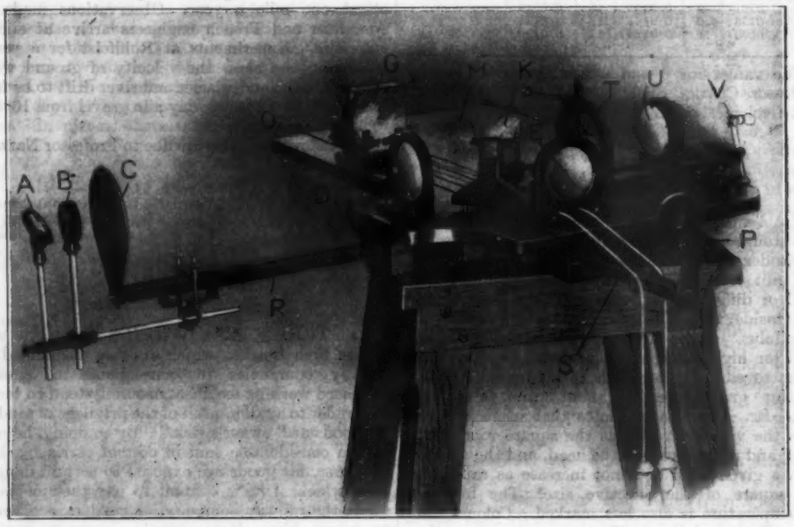
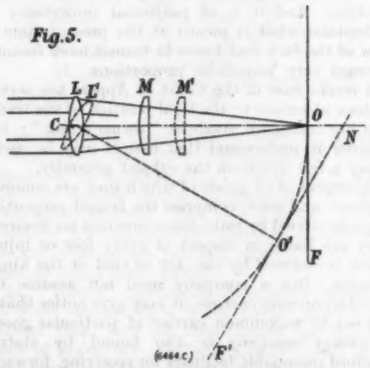


Fig. 2.

Fig. 5.



reference is most convenient to him. The distortion produced by a slight pressure also tells him whether the ring or curve indicates a hill or a valley. When the lengthening of the path of the rays causes the contour lines to widen out so as to enclose a larger area, a hill is indicated, but when the lines crowd up, a valley has to be dealt with. The contour lines do not, however, necessarily indicate the presence of a hill or valley, although they show some imperfection. The map actually shows the total effect on the wave front produced by the double passage of the light through the lens or prism, indicating in wave lengths the departures from planeness of the resulting wave surface.

In ordinary lens testing we have to deal with axial pencils of light. For testing camera lenses with oblique pencils the construction of the interferometer is modified though it remains essentially as described. The table is replaced by a cast-iron wheel, and the lens to be tested is mounted in the centre of the wheel, on a radial arm, so that the beam from K will be parallel to the axis of the lens or form a measurable angle with it. The wheel form is not essential, of course, but the basis of the instrument must be, or the operator may be disturbed by slight vibrations of the instrument, and it is necessary to arrange for the obliquity of the rays to be measured by means of a graduated circumference or arc. As mounted, the lens can be turned about a line at right angle to its axis and passing through the second principal point, and simultaneously with the turning of the lens the convex mirror (corresponding to U in Fig. 2), is automatically moved away from the lens so that its position coincides with the focal plane in which the lens is desired to form its image. The principle is explained by Fig. 5. The camera lens is L (corresponding to T in Fig. 2), M is the reflecting mirror (the U of Fig. 2) and O F marks the focal plane for the case of an axial pencil; the same letters with dashes L^1, M^1, O^1F^1 mark the corresponding positions for an oblique pencil, when the lens has been turned through an angle OCO^1. The mechanism is so arranged that $MM^1 = O N$. The lens can be adjusted both along C O and at right angles to it, by means of screws. The mirror M slides on the radial arm and is so mounted on this arm O C, or $O C^1$, that it is always gently pressed against the bar O F or $O F^1$ (always at right angles to O C). Thus the distance $M M^1$ remains equal to N O when the angle $O C O^1$ is changed, the second principal point being on the axis of rotation.

We now come to the photographs of contour maps. The lens used in the production of Fig. 6 is merely out of focus, the emergent wave-front being spherical instead of plane. Fig. 7 shows the effect when the same lens is almost exactly in focus, but the mirror has been very slightly tilted, to reveal the structure better; the bands are not quite straight, but the test is satisfactory. Fig. 8 was taken with the same lens badly out of focus—a fact which is indicated by the large number of fine bands crowded together—and also tilted so as to produce astigmatism; the elliptical outline of the bands betrays this latter condition. In Fig. 9 the effects of coma (i.e., the asymmetrical distribution of light in oblique pencils), still using the same lens, can be seen. The wave-front, it will be noticed, is practically accurate over a large part of the field, while in the remainder it curls over rapidly. This coma may be removed by placing a diaphragm at suitable distance from the lens. By trial, and with the aid of a pencil and a piece of drawing paper, the proper size and position of the diaphragm can easily be ascertained. Fig. 10, which does not refer to the same lens, exemplifies the effect of interposing a sheet of glass, somewhat better than window glass, but not so good as plate-glass, in the path of the rays.

The remaining figures illustrate several tests of a camera lens made under varying conditions. The lens employed was a good specimen obtained from a firm of high reputation; the diagrams, however, do not show the actual construction. All the photographs were taken with full aperture. In Figs. 11 and 14 the light beam is normal, and the aberration spherical and of the type already illustrated in Figs. 3 and 4. The diagram, Fig. 11, shows the shape of the wave-front on a diametrical section. In Figs. 12 and 15 the pencil is oblique, the obliquity of 7½ deg. to the axis, corresponding to a point 1 cm. from the centre of the photographic plate. The wave-front is no longer travelling straight on, but is moving towards a point to the side of the

ideal position. The effect would be the same if the lens were distorted, but the figure was actually produced by a faulty adjustment of the lens, which was not appear as in Fig. 11, but considerable asymmetry will be displayed outside the central portion.

In order to explain what the contours seen signify and how the maps can be utilised for correcting imperfections, we will refer back to Fig. 11. Counting from the centre we see four and a half wave-lengths of aberration, four being distinct, the fifth indistinct near the edge of the field of view. All the aberrations are doubled by the interferometer, as above stated, because the rays pass twice through the lens under test. The aberration of the wave-front would therefore, after passing once through the lens, amount to two and a quarter wave-lengths, which is nine times the aberration of one quarter wave-length which Rayleigh considered permissible for a good lens. The correction is effected in the following way:—The operator having his eye in front of P, Fig. 1, sees a contour map such as we have illustrated. By touching the lens with a fine-hair brush he can easily find a spot on the glass lying on one of the curves he sees, and it is thus possible to trace out the contour lines on the actual lens surface. The operator then mounts the lens on a spindle and grinds off the hills. During this operation he has the interferometer close to the bench so as to be able to check his work readily. The work requires some practice, but is not exceptionally difficult, and may well be done in the course of a few hours. When the corrections are considerable, more time is required, chiefly because the lens becomes heated in the process of grinding, and has to be allowed to cool down again before a fresh observation can be taken on the interferometer.

We may add, in conclusion, that Messrs. Hilger for some years have been preparing their metallised glass mirrors by cathode ray treatment. The work is placed in an evacuated glass bell underneath the cathode, a disc of silver, for instance, which should have the same form of surface as the work, i.e., should be plane or curved like it. The vacuum need not be pushed very high; an X-ray vacuum is not required. The distance between the cathode and the work should be such that the latter is just outside the dark cathode space. With currents of 15,000 volts and about 7 milliamperes it will take about 20 minutes to produce a half-silvered mirror; for full silvering an hour is required.

Mr. F. Simeon, who is in charge of these experiments, has also volatilised gold, platinum, and palladium in the same way. Palladium is very easily volatilised, but nickel, which would be preferable for the reflection of ultraviolet rays, is more difficult to deal with. One practical advantage of the process is that it can be repeated if, on examination after removal from the vacuum vessel, the metal film should be found to be not sufficiently dense.

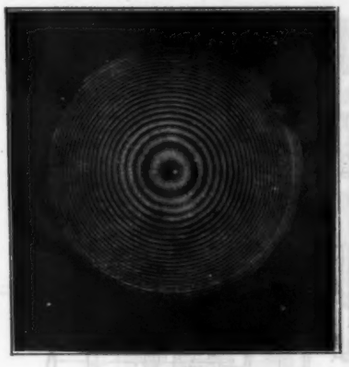


FIG. 6.

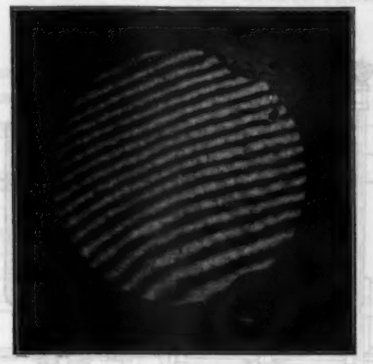


FIG. 7.

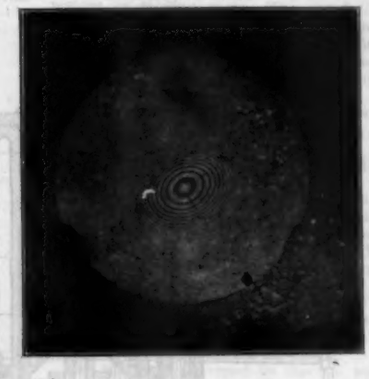


FIG. 8.

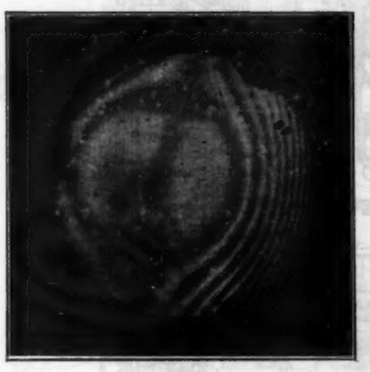


FIG. 9.

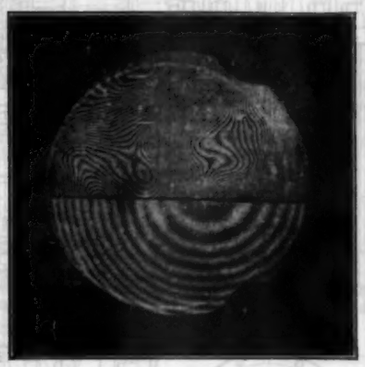
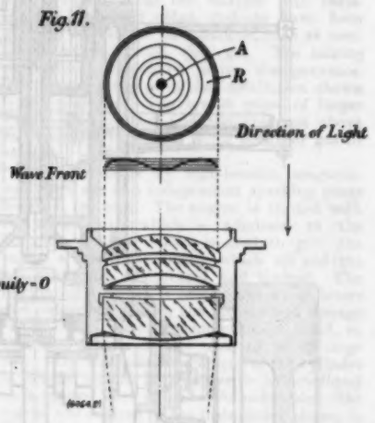
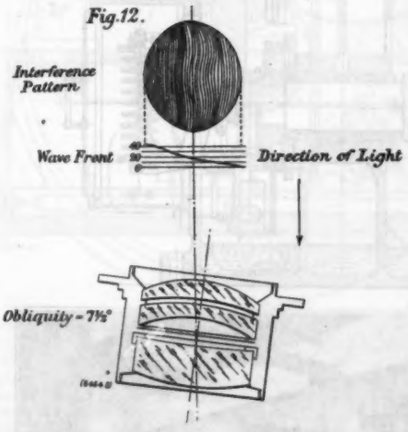
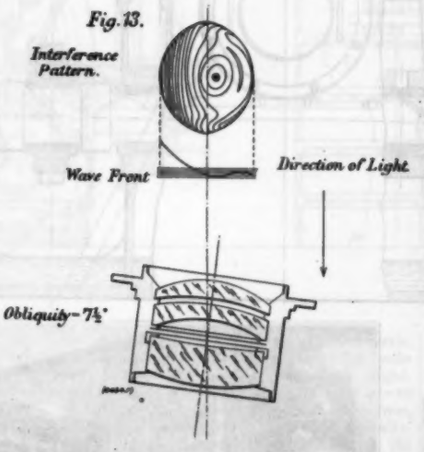


FIG. 10.







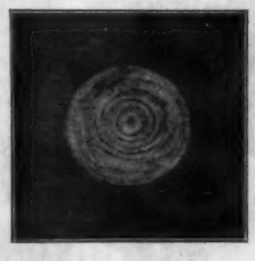


FIG. 14.

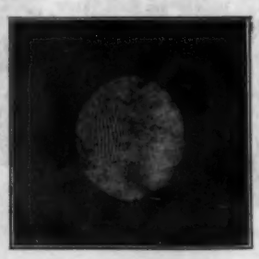


FIG. 15.

FIG. 16.

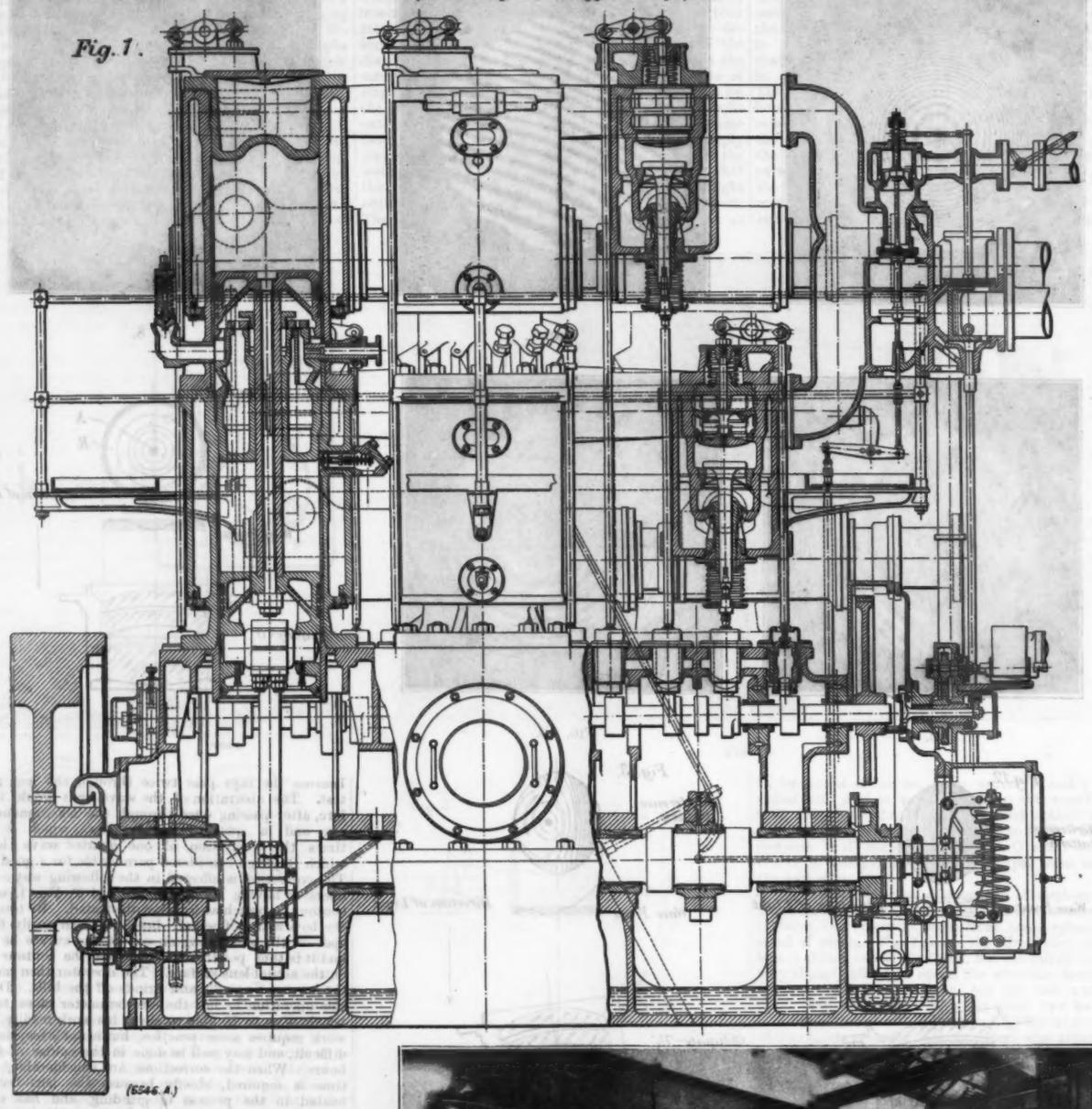
rotated about its second principal point. If the lens is readjusted longitudinally, leaving the tilt of 7½ deg., as in Figs. 13 and 16, the axial pencil will

VERTICAL TANDEM GAS ENGINES.

CONSTRUCTED BY THE NATIONAL GAS ENGINE COMPANY, LIMITED, ENGINEERS, ASHTON-UNDER-LYNE.

(*For Description, see opposite Page.*)

Fig. 1.



(5546.A.)

Proposed Ferry between Denmark and Norway.—For several years a private committee has been paving the way for the establishment of a steam ferry between a port in southern Norway and another in the north of Jutland. The scheme has been well received in influential quarters, and as a result of the labours of the committee, the Danish and Norwegian Governments have recently appointed a joint Commission to go into the matter. This Commission, in the first place, will have to consider the desirability of such a ferry, and if this is established the route will have to be decided. It is expected that the Commission will recommend the speedy establishment of the ferry, and, in the meantime, the first-named committee had discontinued its work.

Canadian Supplies for Steel Industry.—We read in *The Canadian Engineer*, that in a recent address before the Canadian Institute of Mining and Metallurgy, at Winnipeg, Mr. H. E. Knobel stated that there were excellent possibilities of creating a steel industry in Western Canada, based upon purely domestic supplies of iron and coal. He said that Ontario's iron ore and Alberta's coal could be utilised for the production of steel for Western Ontario and the prairie provinces. He further declared that the United States mines, upon which Ontario's furnaces now depend, can last only another twenty-five years. Mr. Knobel was engaged by United States steel companies, for six years prior to the war, to investigate Canadian iron deposits.

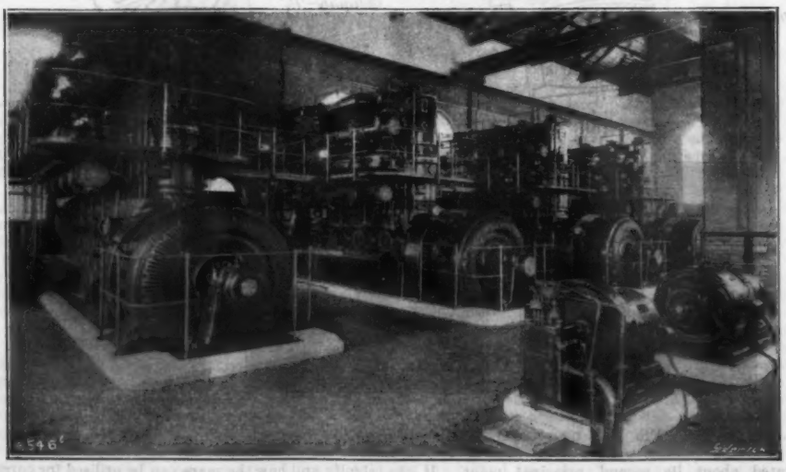
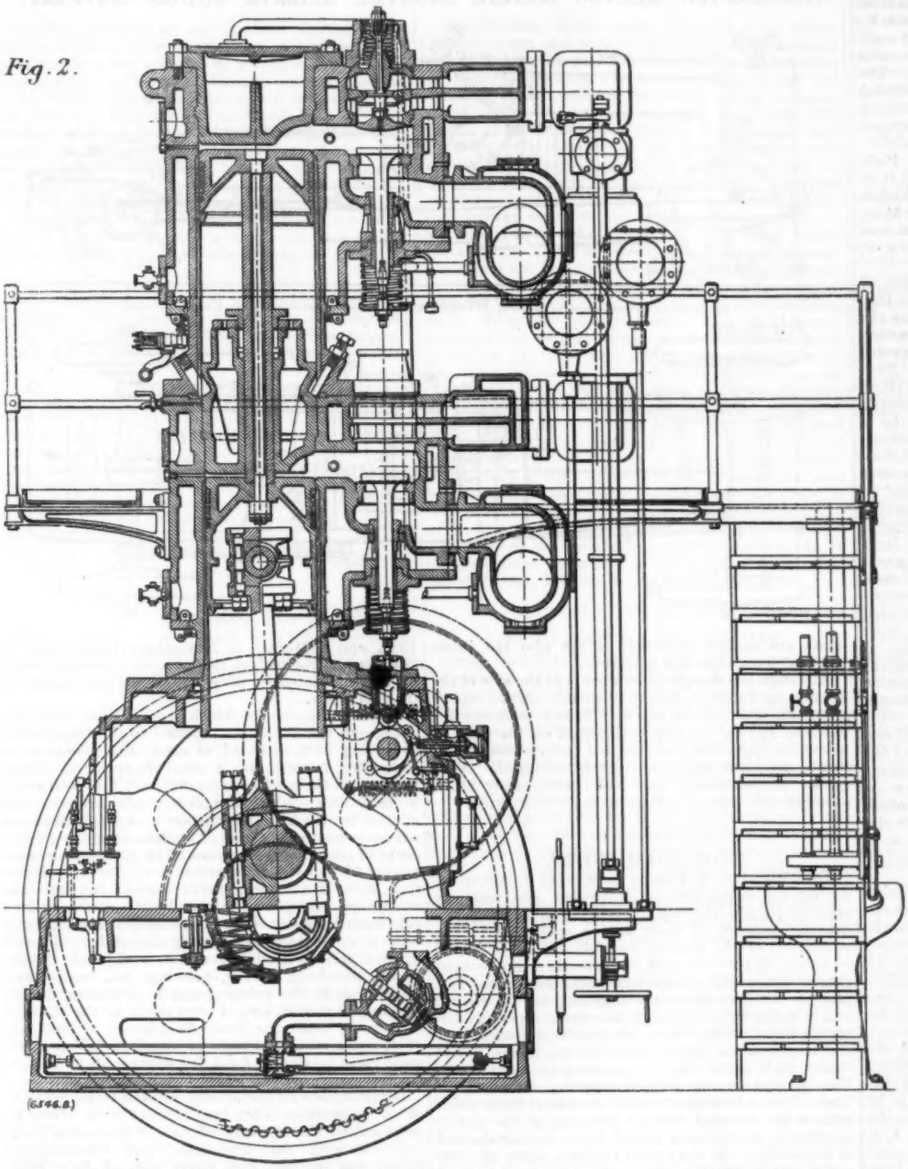


Fig. 3. 600-B.H.P. Vertical Tandem Gas Engines at the Works of the Midland Coal, Coke and Iron Company, Limited, Newcastle, Staffs.

VERTICAL TANDEM GAS ENGINES.

CONSTRUCTED BY THE NATIONAL GAS ENGINE CO., LTD., ENGINEERS, ASHTON-UNDER-LYNE.

Fig. 2.



THE vertical tandem gas engine designed and constructed by the National Gas Engine Company, Limited, of Ashton-under-Lyne, has become so popular a prime mover that within a comparatively short space of time engines totalling over 100,000 brake horse-power have been put into operation in the United Kingdom and abroad. No less than 40,000 brake horse-power are used in driving electrical alternators, so that it may fairly be taken that the service is satisfactory. Most of the engines are running on producer gas, but suction gas, blast-furnace gas, coke-oven and town-gas are also employed.

These engines are built in units up to 1,500 brake horse-power, these large engines having six cranks. All sizes are built upon the unit principle and the range of sizes includes only two sizes of cylinder. For instance, the 300 brake horse-power engine is a two-crank engine with two sets of tandem cylinders, with 18-in. stroke. The 450 brake-horse power engine has three cranks of 18 in., and similar cylinders to the smaller machine. The 600 brake horse-power unit has four cranks with cylinders of the same design. The higher powered units have 24 in. stroke and three, four or six cranks as the case may be.

In Figs. 1 and 2, on this and the opposite pages, we illustrate a 450 brake horse-power engine with three 18-in. cranks and six cylinders. Fig. 3 is an illustration of a power station at the works of the Midland Coal, Coke and Iron Company, Limited, Newcastle, Staffordshire, showing an installation of four 600 brake horse-power units, these being four-crank eight-cylinder engines. The details of design as above stated, are similar. These engines work, of course, on the four-stroke cycle. They are of the totally-enclosed type. The main feature consists of the arrangement of the tandem vertical single-acting cylinders. These are arranged so that the top and bottom cylinders fire alternately, while below the top piston and the cover of the bottom cylinder is a compression space which acts as a buffer or cushion for the reciprocating parts on the downward stroke. The compression of the gaseous mixture itself cushions these parts on the upward stroke. This, with the crank arrangement, gives a very even-running engine, with uniform turning effort. The top cylinders are slightly larger than the lower, in order to facilitate withdrawal of the parts. The difference of diameter actually occurs at the intermediate cover, which is a hollow casting turned on the outside with a collar which fits on to a ledge in the cylinder casting. A copper joint ring is used at the ledge. This cover is held in place by a series of set screws which press on to the lower side of a groove in the cover as depicted in Fig. 2, where the positions of two such set screws are shown, with one in place. They may also be seen in the centre portion of Fig. 1.

The cylinders are fitted with liners which can be replaced. Cooling-water circulation is arranged for the cylinders and covers, but water cooling has not been adopted for the pistons or moving parts. The circulation is of the open type, the outlet pipes from the cylinders, covers, &c., discharging into a funnel so that the temperatures can be readily regulated. The discharge is shown behind the stairway in Fig. 2.

Fig. 1 shows one pair of cylinders in section, one pair in outline, and in the third unit gives a section through the valves and cam gear. The valves are worked from a camshaft driven by gears from the main shaft. The cams operate small plungers fitted with rollers, and these plungers actuate the valves by means of push rods, either direct or through rocking levers, the former in the case of the exhaust valves and the latter in the case of the inlets. In order to facilitate examination, &c., the valves are staggered, as will be seen in Fig. 1. The cam motion, &c., is all completely enclosed. The bearings, pins, &c., are furnished with forced lubrication.

The engine is governed by throttle worked by a centrifugal governor shown at the right-hand end of the engine in Fig. 1. Normally quantity-governing is used, but it can be arranged to change the mixture with variation of load, and other systems have been adopted in various installations, such as combining exhaust with rich gas. The mixing arrangement is shown above the governor. The uppermost pipe in the installation shown is for coal gas. The lowest pipe, of larger diameter, is for air, and the one just above it, of similar diameter, is for producer gas or exhaust.

The ignition is by high-tension magneto, and there are two independent sparking plugs for each cylinder. The engine is started with compressed air, which is admitted to the bottom cylinders. This is used to give the engine a few turns during which air and gas are drawn in, compressed and ignited. The auxiliaries required consist of the water tower and pump, and the air compressor and storage tanks. The water consumption is small, so that the former do not need to be of large size. The vertical arrangement of the cylinder in tandem enables large power to be developed on a limited floor space. We understand that one of the engines in the installation shown in Fig. 3 ran last year 84 per cent. of the possible time, so that the type is clearly suited for continuous running, while their ease of starting makes them admirable stand-by machines.

FAR EASTERN TRADE OF THE UNITED STATES.—The Far Eastern Division of the United States Bureau of Foreign and Domestic Commerce, says *The Board of Trade Journal*, has issued a summary of the total trade of Asia and Oceania, which comprise the Far East, with the United States for the eight months ended August, 1920. The total trade is valued at 1,870,556,213 dols., and reveals an increase of 563,518,916 dols. over the same period of 1919, when the trade under consideration amounted to 1,307,037,297 dols. This Far Eastern commerce constituted approximately 20 per cent. of the total foreign trade of the United States during these eight months of 1920, as compared with 17 per cent. in 1919. The United States exported merchandise to the Orient during the first three-quarters of the current year to the extent of 754,901,844 dols., which represented an increase of 134,712,998 dols. over the first three-quarters of 1919; while imports from the Far East attained a value of 1,115,654,369 dols., or an increase of 428,805,918 dols. This export trade amounted to 13¼ per cent. of the whole and the import trade to 28 per cent. Of the Far Eastern countries receiving these exports Japan led in purchasing 328,663,681 dols. worth this year, and 240,505,570 dols.' worth during the first three-quarters of 1919. The smallest amounts went to the Dutch East Indies, aggregating 34,995,550 dols. for the eight months of this year and 36,266,200 dols. in 1919. The other countries, in the order of the value of their imports from the United States, were as follows: 1920—China, 96,311,017 dols.; Australia, 73,054,230 dols.; British India, 65,744,078 dols.; and the Philippine Islands, 61,090,161 dols.: 1919—Australia, 73,488,625 dols.; China, 70,397,978 dols.; Philippine Islands, 52,358,917 dols.; and British India, 47,056,457 dols. Imports from these countries have shown a similar tendency to vary slightly in the order of value; 1920—Japan, 339,473,303 dols.; China, 161,762,861 dols.; British India, 138,101,524 dols.; Dutch East Indies, 74,670,626 dols.; Philippine Islands, 74,547,402 dols.; and Australia, 38,368,079 dols.: 1919—Japan, 216,194,391 dols.; China, 87,826,585 dols.; British India, 75,135,516 dols.; Philippine Islands, 44,546,967 dols.; Dutch East Indies, 41,897,874 dols.; and Australia, 39,704,986 dols.

THE SIX-CYLINDER MINERVA CAR.

One of the most interesting cars exhibited at the recent Motor Show was the six-cylinder Minerva car, which we illustrate on Plate LXXV this week, and on the present page. This, as is well-known, is made by the Société Anonyme Minerva Motors, of Antwerp, and during the war the Germans removed all the tools from the factory, transporting them to Germany. The company, however, bought new machinery during the war and also kept an experimental factory running in Holland and, therefore, were soon able to recommence manufacture when the war finished.

The engine which is shown in Figs. 1 and 2, Plate LXXV, is of the Knight sleeve valve type and is an extremely good example of this system. The cylinders are 90 mm. diam. by 140 stroke (approximately 3½ in. by 5½ in.). It develops 88 b.h.p. at 2,100 r.p.m. and retains its full torque down to 1,700 revolutions, at which speed it develops 75 b.h.p.

Contrary to the practice of some other builders of sleeve valve engines, the cylinders are all cast *en bloc*. This makes a very clean-looking engine, and has the great mechanical advantage that the cylinder casting very much stiffens the crank case. This is an important matter in an engine which runs at a high speed. Each cylinder has a separate head carrying the junk rings, and the tops of these heads are open to a common water chamber, the top of which is closed by a single cover running the length of the cylinder casting. Light hollow gudgeon pins are used and also hollow connecting rods. These are somewhat more expensive than the usual stamped H section, but are rigid in every direction. It will be seen that both connecting rods and big ends are very light yet of ample strength. The crank shaft has seven bearings and is of large diameter with substantial webs. Both connecting rods and crank shaft are machined all over. The shaft driving the sleeves is also carried on seven bearings. It is driven by silent chain. The crank shaft is located endways by a double ball thrust at the front end, none of the main bearings touching the crank webs. A vibration damper is carried at the front end of the shaft consisting of a small flywheel driven by a friction clutch. Lubrication is entirely by splash from troughs into which dippers from the big ends dip. The oil is sucked from the sump by a rotary pump which delivers it to a distributor and this delivers it to each of the troughs in turn. This is more reliable than having a pipe running along the troughs with a hole for each, as one of these holes may easily get stopped up, in which case that big end runs dry. It is also much simpler than having a separate pump for each trough as is sometimes done. A very neat combined drain and oil level cock is fitted shown at A, Fig. 2.

A Zenith twin carburettor is fitted, and this takes its air through the crank case. This warms the air, cools the crank case and keeps a slight vacuum in the latter which prevents oil leaks. An alternative supply which can be opened at will, allows of part of the air being drawn direct into the carburettor in hot weather. In testing, the engines are driven by belt for two hours, then tested for three days, dismantled for examination and then tested again.

S.E.V. generator, starter, and magneto are used, the generator being gear driven and the magneto driven through the generator. These are placed on the exhaust side of the engine. Water circulation is by a gear-driven pump. A cone clutch transmits the power to a four-speed gear box shown in Figs. 3, 4, 5, and 6. This is of substantial construction with good diameter splined shafts on which the sliding gears have an exceptionally long bearing. All the shafts run on ball bearings, most of which have two rows of balls. The speedometer drive is incorporated in the gear box. The constant mesh wheels have helical teeth to reduce the noise. A powerful foot-brake of the expanding type is carried at the back end of the gear box. The foot brake drum is balanced. The back axle is shown in Figs. 7 and 8, and is both simple and strong. It is of the spiral bevel type with bevel differential. A distinctive feature is that no special thrust bearings are provided, the ball bearings being in all cases specially designed to take both load and thrust. A detail of one bearing is given in Fig. 8. This design very much simplifies the construction. Great care is taken to prevent oil leaks.

The general arrangement of the chassis is shown in Figs. 9 and 10. The front springs are the usual semi-elliptical form. The back springs are cantilever. These take the drive and have three of the leaves very rigidly clamped to spring seats which can rotate on the axle, but not move in any other way. The torque is taken by a tube surrounding the propeller shaft, which is hung to a cross member a little behind the gear box. Both ends of the propeller shaft have universal joints, the front being of the cross pin type, the back a sliding block joint. The latter runs practically straight; the former is lubricated with thin grease from a special pump supplied with the car. Both joints are entirely enclosed, as are also the joints between the clutch and gear box.

Although the change speed lever is at the side of the car and not in the centre, it is entirely carried on the gear box and can be set in different positions for different bodies. A primer is placed on the dash to prime the engine for starting, and the various instruments, &c., are very conveniently arranged. Altogether this chassis is very well worth study as an excellent example of modern motor construction.

THE SIX-CYLINDER MINERVA CAR.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME MINERVA MOTORS, ANTWERP.

Fig. 9.

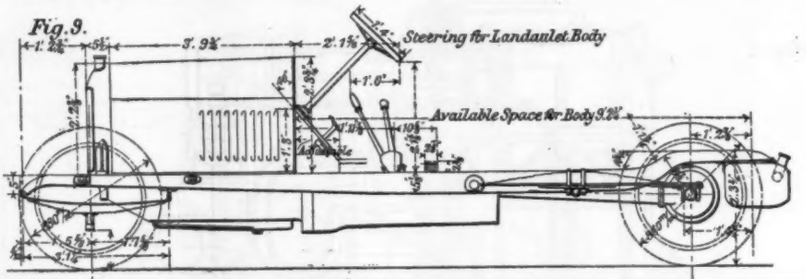
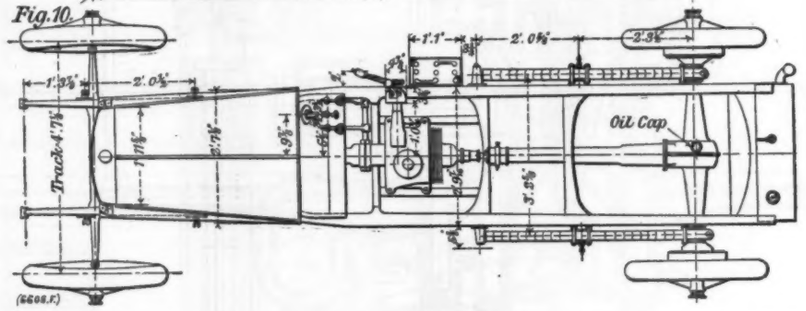


Fig. 10.



(2608.r)

INDUSTRIAL NOTES.

The Ministry of Labour state that employment during the early part of November was seriously affected by the shortage of fuel resulting from the general stoppage of work at the coal mines. The settlement of the dispute was followed by a partial recovery, but at the end of November employment generally was still considerably worse than in the first part of October, before the beginning of the strike; and in many of the principal industries, especially the textile and clothing trades, the furniture trades, boot and shoe manufacture, and the leather trades, it was slack, with much unemployment and short time. The proportion unemployed among members of Trade Unions (mainly of skilled workmen) from which returns are received was 3·7 per cent. at the end of November, as compared with 2·2 per cent. at the end of September. At the end of October, when the coal strike was in progress, the percentage (exclusive of coal miners) was 5·3. The proportion unemployed on November 26 among workpeople covered by the new Unemployment Insurance Act, which came into operation in November, was also 3·7 per cent. The number of workpeople on the Live Registers of the Employment Exchanges at the same date was 520,353, of whom approximately 374,000 were men, 103,000 women, and the remainder youths and girls. In addition, large numbers of workpeople were on short time.

The total number of trade disputes, involving stoppages of work, reported to the Department as beginning in November, was 60. In addition, 76 disputes which began before November were still in progress at the beginning of that month. The majority of these disputes arose on questions of wages. By far the most important dispute was that involving about 1,100,000 workpeople in the coal-mining industry, which began in October and continued until November 3. The total number of workpeople involved in all the disputes in progress during November (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 1,138,000, as compared with 1,200,000 in the previous month and 98,000 in November, 1919. The estimated aggregate duration of all disputes during the month was about 3,631,000 working days, as compared with 13,474,000 in October, 1920, and 1,907,000 in November, 1919. Both in October and November, 1920, the heavy loss of working time indicated by these figures was due mainly to the coal strike.

In the industries for which statistics are available, changes in rates of wages reported to the Department as having been arranged to come into operation in November resulted in a total increase of nearly 690,000*l.* in the weekly wages of nearly 1,900,000 workpeople. The principal industry affected was coal mining, in which over 1,200,000 workpeople obtained advances under the terms of settlement of the general strike of coal miners; persons of 18 years and over receiving 2*s.* a day or shift, and others 1*s.* or 9*d.* a day or shift, according to age. Similar increases were given to workpeople engaged in iron and shale mines, and to coke oven workers. Other large bodies of workpeople who received increases during November included woollen and worsted operatives, workpeople in the textile bleaching, dyeing, printing, &c., trades, and workpeople in the printing and book-binding trades. During the month, Orders were made by the Minister of Labour, under the Trade Boards Act of 1909 and 1918, fixing minimum rates of wages, or raising minimum rates previously fixed, for workpeople in various trades.

On December 1st the average level of retail prices of of all commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel and light, and miscellaneous items) was 169 per cent. above that of July, 1914, as compared with 176 per cent. on November 1. The decrease during the month was mainly due to the reduction of 4*d.* per lb. in the price of sugar. There were also reductions in the prices of clothing, the effect of which was almost exactly counterbalanced, however, by increases in the prices of milk, eggs and fish. For food alone, the increase on December 1 over the level of July, 1914, was 182 per cent., as compared with 191 per cent. on November 1.

The Prime Minister received last week at the House of Commons a deputation representative of a number of municipalities, urging that the Government contribution towards the cost of labour on schemes for the relief of unemployment be increased from 30 per cent. to 75 per cent. In reply, Mr. Lloyd George said the request was not in the power of the Exchequer to grant. It could only be done by imposing further taxes, which would excite a great deal of antagonism. The present burdens of the taxpayer were five times, and those of the ratepayer were twice the pre-war figures. In the course of his speech to the deputation, Mr. Lloyd George added that by co-operation alone, not merely co-operation between local authorities and the Government, but between all classes, would this country be able to solve the problem of unemployment. "If each department, whether Governmental, municipal, employer, or worker stands upon rights and privileges,

with no regard to one's neighbour, there will be suffering; but if we all do our best to assist, then, I think, we shall be able to pull through, and to pull through without too much suffering."

Speaking recently at the Seaham Harbour Constitutional Club, Sir Arthur F. Pease said he was afraid unemployment was going to be a very serious matter. It meant that we would all have to put our shoulders to the wheel. He would like to see both employers and employed take the rather drastic step of being satisfied with small profits and comparatively small wages, and cut costs down, so as to meet the world competition. He was afraid, however, that this would not be done. In America they made what was called "the cut," and got down to the bottom and then began to come up again. He thought we should try to get down to a position of stability as quickly as we could, to give ourselves a chance of climbing again.

It is stated that nine of the principal spinning mills in Belfast closed down for five weeks at Christmas, owing to depression in the linen trade. The stoppage involves about 30,000 operatives.

Our attention has been called to the Industrial Publicity Bureau, having offices at 11, Archer-road, Penarth, Cardiff. The Bureau expresses the opinion that the tasks of statesmen and captains of industry would be made far easier if the people were less suspicious, and they would be less suspicious if they understood the problems which industry has to face. It has, therefore, decided to start a system of educative propaganda for the workers, in the shape of "Pay Day Talks," or folders explaining the industrial problems now before the world.

The coal output in Great Britain for November was 15,919,100 tons. It amounted to 5,176,200 tons for the week ended December 4, to 5,205,400 tons for the week ended December 11, and to 5,307,000 tons for the week ended December 18.

The Secretary for Mines states that in view of the increased output and the falling industrial demand in certain directions the Inland Supplies Co-Ordinating Committee of Coal Owners, Coal Factors and Merchants have advised that it is desirable to allow a certain amount of local coal to be used for foreign bunkering in the Mersey, and to allow the use for foreign bunkers or export of a certain amount of large coal at Humber ports provided that it is sold with a proportion of slack. The latter arrangements will come into force at once, and the arrangements as to bunkering in the Mersey about the middle of January, when there has been time to re-adjust the present system. In both cases the supply of coal will be by permit from the local Coal and Coke Supply Committees concerned. The arrangement is experimental, and is subject to the inland supplies being properly met.

NOTES ON NEW BOOKS.

It is a commonplace that scientific men in general have difficulty in explaining either the outlines, or the details, of their science in such a way that they may be understood by the general public. This difficulty however, is not peculiar to the practitioners of the more abstruse flights of pure science, and it is not very usual to find exponents of any technical process who are capable of presenting it in such a way that it may be comprehended by anyone having absolutely no initial knowledge of the matter. There are, of course, no short cuts to an adequate knowledge of any subject, but a general comprehension of an abstract subject, or a working knowledge of a technical one, may be given by a competent teacher. As a by-product of the increase in the use of engineering and scientific appliances in general life a large number of hand-books of one kind and another have been published in order to enable the non-technical user to obtain a working knowledge of the appliance, or plant, with which he is concerned. Some of these books are fairly good and some of them are very bad, but as a really excellent example of the former class we would commend "*The A.B.C. of Storage Battery Management*," by Mr. Ernest C. McKinnon. This book, which is published by the Electrical Press, Limited, of Fisher-street, Southampton-row, London, at the price of 3*s.* 6*d.*, is intended to enable the non-technical storage battery user, of which there are many, to understand what is going on inside the battery and, more particularly, to enable him to operate the battery both to its and his own benefit. It is difficult in reading through a book of this kind absolutely to take the point of view of the man who has never heard of an ammeter, but as far as we can judge if such a man takes the trouble to read the book carefully it will really enable him to run his country-house lighting battery, or whatever it may be, in a satisfactory and efficient manner.

A publication which should prove of great utility to shipbuilders and structural engineers has recently been issued by Lloyd's Register of Shipping, bearing the title "*Geometrical Properties of Ship Girders and Sections*," and consisting of tables giving sectional areas, centre of gravity, moments of inertia and moduli of resistance for angles, bulb angles, and channels, both individually and in conjunction with other sections and plating. It should, perhaps, be explained that these tables were originally compiled in order to facilitate the technical work of the Register, and having satisfactorily fulfilled this function, it was thought by the Committee that they would prove equally useful to others engaged in similar work. The tables are based on the British standard sections, as revised in 1914, and they include a range of sizes sufficient fully to meet the requirements of shipbuilding work. They are clearly printed and conveniently arranged, the data for simple sections being generally placed on one page with the corresponding data for the same sections in conjunction with plating on the facing page. The high reputation of Lloyd's Register for accuracy in the production of tabular and statistical matter leaves little room for doubt that typographical errors have been eliminated, which is a matter of considerable importance in a work of this nature. If we may make one suggestion, it would be that future editions should be provided with a thumb, or tab, index on which the outlines and main dimensions of the sections might be printed to facilitate reference. The price of the book is 21*s.* post free, and it can be obtained from the offices of the Register, at 71, Fenchurch-street, London, E.C. 3.

YEAR-BOOKS AND ANNUALS.

Daily Mail Year-Book, 1921.—This well-known handy volume for 1921, the twenty-first year of issue, like the preceding editions, contains a very large amount of information on practically every topic, and a number of special articles by prominent men. To deal only with a small part of the field it covers, we may mention that it gives particulars concerning the advance made in wireless telegraphy, road *versus* rail transport, articles on labour, the world's airways, British ships and shipping, articles and statistics concerning British trade, together with numerous other data on engineering, finance, politics, &c., besides biographical and sporting information, and a quantity of other useful items, reference to all of which is facilitated by a very detailed index. It is edited by David Williamson, and is published at the price of 1*s.* 6*d.* net by Associated Newspapers, Limited, Carmelite House, E.C. 4.

Industrial League and Council Pocket Diary.—We have received from the Industrial League and Council, Grosvenor-mansions, 82, Victoria-street, S.W. 1, a copy of their pocket diary for 1921, measuring 4¼ in. by 3¼ in., four days to a page, giving the names of the officers of that body, of the Federation of British Industries, the National Confederation of Employers' Organisations, and of other employers' and employees' associations and trade unions, together with other information.

Almanacks, &c.—We have received from a number of firms almanacks and calendars, many of which are of artistic design, all being of a serviceable character. Messrs. Henry Simon, Limited, Manchester, have sent us their daily tear-off calendar. A monthly, highly decorative tear-off almanack has come to hand from Messrs. Sir W. G. Armstrong, Whitworth & Co., Limited, each of the twelve sheets bearing the reproduction of a landscape or seascape; also one from Messrs. Mawdsley's, Limited, Zone Works, Dursley (Glos.). Clearly printed, monthly tear-off calendars are those sent by Messrs. Geo. Cradock & Co., Limited, Wire Rope Works, Wakefield; Messrs. Peckett & Sons, Limited, Locomotive Works, Bristol; Messrs. Hulse & Co., Limited, machine tool makers, Ordsal Works, Manchester; Loughborough College of Arts and Sciences; the Associated British Machine Tool Makers, Limited, 17, Grosvenor-gardens, S.W. 1; Messrs. Clayton, Son & Co., Limited, Hunslet, Leeds, manufacturers of gas-holders, tanks, boilers, &c. (for four years, down to December, 1924); Messrs. Rd. Johnson Clapham & Morris, Limited, 24 and 26, Lever-street, Manchester; Messrs. The Brown Hoisting Machinery Company, Cleveland, Ohio; Messrs. Abdulla & Co., Limited, 173, New Bond-street, W. 1; Messrs. Hugh Wood & Co., Limited, makers of "Jeffrey" coal cutters, Newcastle-on-Tyne; Messrs. Brown Brothers, tool manufacturers, Great Eastern street, E.C. 2. We have received daily tear-off calendars from Messrs. Commercial Cars, Limited, Luton; Messrs. Pirelli & Co. (Pirelli tyres), 144, Victoria-street, E.C.4; the Davenport Engineering Company, Limited, Bradford, manufacturers of the Bradford patent water coolers. We have also received a monthly tear-off calendar from the British Piston Ring Company, Limited, Brico Works, Coventry, giving a reproduction of the painting by Montague Dawson, Lieutenant R.N.V.R., depicting the surrender of the German fleet.

COLD-STORAGE BOATS "RHENANIA 13 AND 14."

In our issue of June 4 last, page 756, we briefly described the cold-storage barge Köln 13 which Germany had to build for the Allied Army on the Rhine. The two other boats built for the same purpose differ in several respects from the Köln 13 (*Zeitschrift des Vereines Deutscher Ingenieure*, November 6, pages 932–936). The following figures show the two new boats, Rhenania 13 and 14, to be much alike: length 82·5 m. (271 ft.), beam 10·2 m. (33 ft.), draught under full load 2·1 m. and 1·78 m. (70 in. and 83 in.), cold-storage load 480 tons and 485 tons, load capacity 1,177 cub. m. and 1,195 cub. m., weight of barge empty 320 tons. The boats were built of mild steel by C. Ruthof, of Mainz; the machinery was supplied by the Maschinenfabrik Humboldt, Kalk near Deutz, and the refrigerating plant by A. C. Pohlmann, of Frankfurt. The Köln 13 had been designed to keep the temperature down to about − 5 deg. C. (23 deg. F), but this could not quite be maintained on very hot days in the docks when the hatches were open, and the capacity of the refrigerating machinery was therefore increased on the Rhenania boats by one-third. The main engines are, in each case, a 35 h.p. benzene motor with an auxiliary benzene motor of 14 h.p.; there are two compressors. Two air coolers (ammonia) each of 84 sq. m. (904 sq. ft.) surface have been installed in the engine-room. Electric fans of 3 h.p. draw the air from the upper portions of the hold, lower the temperature to − 10 deg. C. (14 deg. F.), and return it to the hold; the air-trunks are of wood, and run below the deck. There are also distribution pipes, partly smooth on the outside (93 m. in length) and partly provided with fins, 14 mm. (5·7 in.) in diameter; the latter have a length of 338 m. (1,109 ft.). The heat insulation is largely effected by sterchamol, a baked infusorial earth containing algae, which produces a highly-porous and light mortar. The insulation of the bottom of the Rhenania 14 consists of 6·5 cm. of this sterchamol, two layers of shallow air cells, and one layer of deep air cells; 13 cm. of sterchamol-concrete, 3 cm. of cement, 10·5 cm. of cork, and finally, 4 cm. of ferro-concrete. Next to the ship's skin at the sides are 6·5 cm. of sterchamol stones; then 16·5 cm. of cork in two layers, 10 sheets of impregnated paper pulp, and finally wood panelling of 1·5 cm. thickness. In the deck we find, starting from above, 3 cm. of planking, 4 cm. of air space, a sheet of paper pulp, 6 cm. of cork, again 3 cm. of wood, a 3·5 cm. air space, 10·5 cm. of cork and 2·5 cm. of wood panelling. On the Rhenania 13 the deck was strengthened by means of concrete to carry deck loads, if necessary, the total thickness amounting to 36 cm. (14 in.). The refrigerating plant of the Rhenania 14 has a total weight of 486 tons, made up as follows: engines with beds, 60 tons; pipes, 20 tons; air trunks, 30 tons; insulation, 370 tons; accessories, 6 tons. Owing mainly to the concrete deck, which was finally not wanted, the corresponding weight of the Rhenania 13 is much higher, 727 tons, the insulation including the concrete alone weighing 595 tons. The completion of the Rhenania 13 was delayed by the Rhine floods of last winter, so that the boat made its first journey to Antwerp only in May last; the return journey up the Rhine took eight days. The Rhenania 14 has been in service since October, 1919.

TORPEDO-CARRYING AEROPLANES.—In connection with the discussion now being carried on as to the value of the capital ship in naval warfare, our attention has been called by the Blackburn Aeroplane and Motor Company, Limited, Olympia, Leeds, to the effect which torpedo-carrying aeroplanes may have upon the ultimate decision. In comparison with other means of conveying and discharging torpedoes, it is pointed out that the torpedo-carrying aeroplane is able to surprise an enemy in the same way that a submarine can, but does not suffer from the low speed and poor manœuvring properties of the latter. The former also has the important advantage that it is able to get quite close to its target before discharging the torpedo; hence the percentage of hits should be high. Since consideration is now rightly being given to economy in expenditure upon armaments, a strong argument in favour of the new weapon may be drawn from the fact that, for each torpedo discharged in a naval engagement, the loss of *materiel* and number of *personnel* employed is about one-eighth as great for torpedo-carrying aeroplanes as for torpedo-boat destroyers. Another important advantage of the former is that they can attack an enemy fleet in harbour or in any other position in which it might be effectively protected from submarines or surface craft. As is well known Messrs. Blackburn have, for several years, specialised in the design and construction of torpedo-carrying aeroplanes, and have, in fact, built the whole of the machines of this type at present in use in the British service. Some particulars of their latest model, which is known as the "Swift," and was exhibited at Olympia last summer, will be found in our issue of July 16, 1920, on page 78.

THE LATE MR. JOHN GEORGE VALENTINE MAIR-RUMLEY.

We regret to have to announce the death, which occurred in his 78th year, at his residence, The Hammonds, Udimore, Sussex, on the 20th inst., of Mr. J. G. V. Mair-Rumley. Mr. Mair (as he then was, the additional name Rumley having been assumed at a later date) served a term of three years' apprenticeship, from 1860 to 1863, under Messrs. Easton & Amos, mechanical engineers, and a further term of three years, to 1866, under Mr. R. Hodgson. During part of the latter period, in 1865 and 1866, he was resident engineer on the Hull and Doncaster railway. On the completion of his apprenticeship he continued to act on the same railway as resident engineer, until 1869, when the line was completed. In the latter year, he was placed by Mr. T. E. Harrison as resident engineer for superintending the works of the Ouseburn viaduct, the Scotswood bridge, the Derwent Haugh bridge and the Wellington viaduct, on the North-Eastern Railway. He left the service of this railway in January, 1873, and took up the post of manager of the works of Messrs. Simpson & Co., Pimlico, his association with this firm lasting until his retirement from active engineering practice in 1899.

Mr. Mair-Rumley was elected a member of the Institution of Mechanical Engineers in 1873, and was a member of council from 1889 to 1899, during which time he took a lively interest in the affairs of the Institution. He did not contribute any papers to the proceedings, but took an active part in the discussions on marine engine trials, waterworks engines, irrigation plant, locomotives and steam engines generally. Both he personally and his firm, Messrs. Simpson & Co., contributed largely to the successful work of the Research Committees inaugurated by the Institution, and in this connection may be mentioned the well-known friction experiments of Beauchamp-Tower, Mr. Mair-Rumley's firm supplying for these the necessary engine power and accommodation free of cost. He also helped considerably in the work of the Marine Engine Research Committee, and in that of the Steam Jacket Committee.

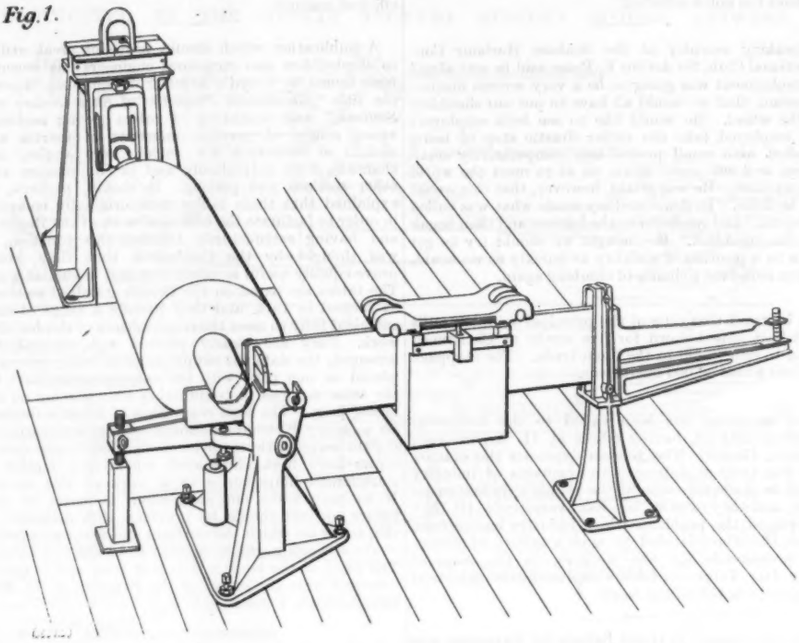
Mr. Mair-Rumley was elected a member of the Institution of Civil Engineers also in 1873, and during the session 1881-82 he was awarded the Watt Medal and a Telford premium for his paper on "The Independent Testing of Heat Engines by the Measurement of the Heat Used," while in the session 1885-86 he also received a Telford premium for his paper entitled "Experiments on the Discharge of Water of Different Temperatures." He further contributed to the Proceedings of the Institution communications on "The Results of some Independent Engine Tests" and "Experiments on a Direct-Acting Steam Pump." His contributions to the discussions on engines for pumping, locomotive engines, steam engines generally and boilers, were numerous and of a thoroughly practical character.

Fractional Horse-Power Electric Motors.—Electric motors of very small power fall within the class of mechanical article which before the war manufacturers in this country were apparently inclined to think either was not worth bothering about or simply could not be made here at a competitive price. This state of affairs was in no way satisfactory, and we are glad to note the excellent work which is being done by Messrs. Scholey and Co., Limited, of Victory Works, Croydon, in the manufacture of electric motors of fractional horse-power. The firm commenced making these motors for special work during the later period of the war, and have since made considerable progress and are turning them out on a commercial scale. Messrs. Scholey use these motors themselves to a large extent in connection with their electric drills and suction cleaners, but they are also supplied independently. The range manufactured runs from $\frac{1}{12}$ h.p. to $\frac{1}{4}$ h.p., and they are available for either D.C. or A.C. circuits up to 220 volts. The $\frac{1}{12}$ h.p. size has an overall length, including the pulley, of 6 in. and a diameter of 3 in.

Progress of the Roma Oil Bore, Queensland.—The Queensland Minister for Mines recently stated that under proper conditions the gas escaping from the Roma bore should yield petrol at the rate of two pints per 1,000 cub. ft. As there were 10,000,000 ft. of gas escaping daily, the petrol content per day now being thrown into the atmosphere was about 2,500 gallons. Experts were now giving consideration as to the best method of dealing with the bore, and whether the gas should be treated for oil or shut off, and further boring for petroleum carried out. The Department has received a number of applications for leases and oil-prospecting licences in the district, but the Government decided they would not grant them. The Government analyst states that when a test was made, the gas was not under complete control, but even under adverse circumstances they got a greater yield than that which paid in America in 1915. In America in 1915, one pint of petrol extracted from 1,000 cub. ft. of gas paid with petrol at 3d. and 4d. a gallon; at Roma they got under adverse circumstances one and a quarter pints per 1,000 cub. ft. with petrol priced in Brisbane at 3s. 9d. per gallon, and he believed it would produce two pints per 1,000 cub. ft.

THE MARTIN ROTOR BALANCING APPARATUS.

Fig. 1.



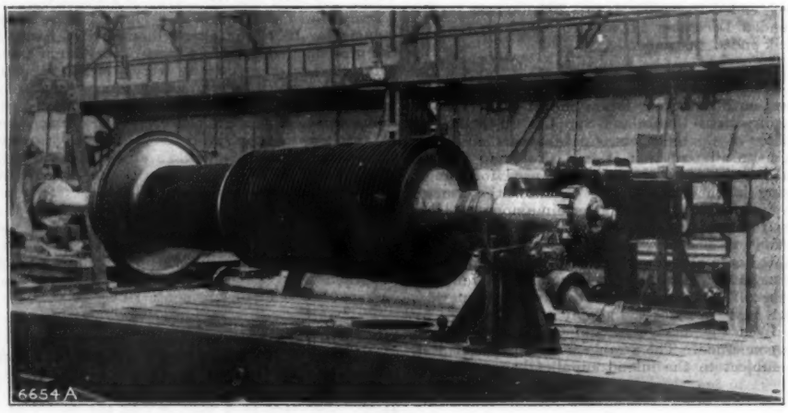


Fig. 2.

The apparatus described and illustrated in Figs. 1 to 5 herewith has been devised by Mr. W. H. Martin, of Messrs. F. A. Pullen and Co., Empire Works, Vauxhall, S.E. 11, from whom a letter on the balancing of rotors is printed elsewhere in this issue of Engineering. This machine affords a quick and inexpensive method of balancing rotary bodies, and gives very accurate results. In an existing machine the sensitiveness of the balance is such that when, for instance, balancing a rotor of 10,000 kg. it will easily show a variation of balance of 1 kg./cm. by sliding the weight of 1 kg. along the beam. This corresponds to a deviation of the centre of gravity of the rotor in a horizontal direction off the axis of 0·0005ths of a mm., or approximately one-fifty thousandth of an inch.

To express the above result in a more concrete way, when, for example, balancing a 10-ton Zoelly rotor of 6 ft. diameter, an overweight of 10 grammes ($\frac{1}{3}$ oz.) on its circumference, or one-millionth part of the rotor's weight, can be readily detected. It is possible to detect, locate and correct an "out-of-balance" moment of one inch-pound present in a rotor or such like.

The machine as adapted for balancing large parts is illustrated in Figs. 1 and 2. It consists of two main portions arranged to carry the shaft of the rotor to be balanced. At one end the shaft is hung in an universally-jointed stirrup, a view of which is given in Fig. 3. The shaft is carried at the other end in a bearing which is mounted on the short arm of a steelyard lever. This will be seen in Fig. 2, while a view of this bearing is given in Fig. 4. The steelyard is provided with a main weight, on which rides a small jockey weight. The steelyard is furnished with knife-edge supported by a short column. On the rotor to be balanced being placed in the bearings the main weight of the steelyard is adjusted till the arm is in equilibrium. The rotor is then turned a few degrees, and the arm is then adjusted by moving the small jockey weight, and this adjustment recorded. The rotor is then turned through another section, and the necessary adjustment again made with the jockey weight. The process is continued for a complete revolution, the rotor being slightly lifted each time clear of the bearing at the steelyard end of the shaft. The results are plotted to a horizontal base, and the sine curve obtained shows a maximum and a minimum which indicates the points at which the centre of gravity is furthest from, and nearest to, the supporting point of the balance. From the moment given by the jockey weight multiplied by its displacement, the eccentricity of the centre of gravity, and the necessary correction are obtained. Fig. 5 shows a small apparatus adapted to the balancing of gyro wheels, of which some results are given in the table below. Some results which have been obtained with the large machine are given in the table on page 865.

That this balancing apparatus is suitable for extremely small and accurate work will be seen from the following result obtained on the small size machine on this principle by Dr. Archibald Barr (Regius Professor of Glasgow University) at his range-finder works, Glasgow.

Rotary Body Balanced.	Weight Kg.	Out of Balance Kg/cm.	Weight Removed Kg.	C.G. Correction. Mm.
A gyro wheel of 5½ in. diameter for a gyrostatic compass	2·973	0·00036	0·000054 (54 milligrammes).	0·00121 (about 1/20,000th inch)

It would, in fact, be possible to detect an eccentricity of the centre of gravity of such a gyro-wheel to within

THE MARTIN ROTOR BALANCING APPARATUS.

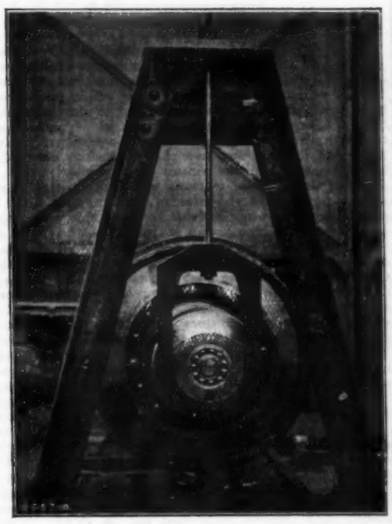


FIG. 3.

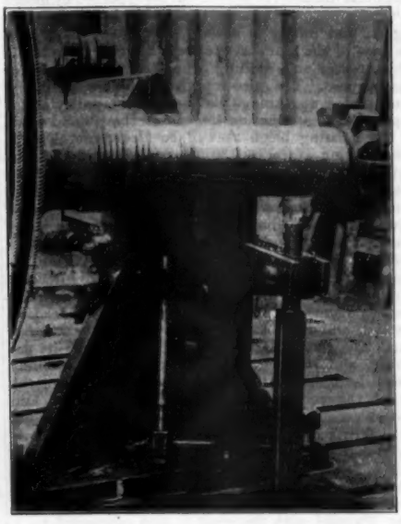


FIG. 4.

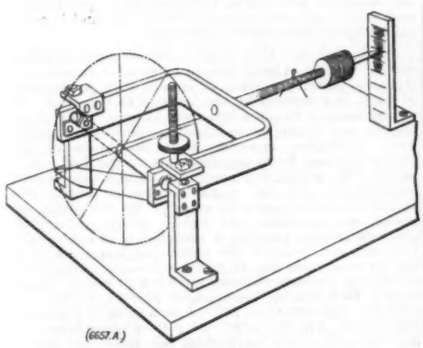


FIG. 5.

one hundred thousandth part of an inch on this small balancing machine.

Recently the excessive vibration set up in a power house and neighbouring houses by an unbalanced armature of a 450 h.p. steam-driven dynamo set was entirely remedied, after balancing on this machine.

Results obtained with Martin's Balancing Apparatus.

Rotary Bodies Balanced on the Machine.	Weight.	Out-of-balance Moment Found.	Weight Removed (Dependent on the Radius).	Corresponding correction of turbine rotor's Centre of Gravity.
	Kg.	kg./cm.	kg.	mm.
H.P. turbine rotor	2678	3·75	0·208	0·014
L.P. turbine ..	5370	5·8	0·23	0·0108
H.P. turbine ..	6792	36·0	1·35	0·053
L.P. turbine ..	9103	13·2	0·244	0·0145
H.P. turbine ..	6781	21·7	0·8	0·032
L.P. turbine ..	9216	34·1	0·695	0·037
H.P. turbine ..	7200	10·8	1·391	0·015
L.P. turbine ..	9203	58·9	1·1	0·064

One 1,500 h.p. set (cargo); one 4,000 h.p. set (cargo); two 4,000 h.p. twin-screw set for passenger liner, and some similar sets since.

Another advantage of this apparatus is that it indicates the correct plane in which this overweight lies, and its moment would act. By any rotary method of balancing this plane can only be approximately arrived at. This feature of being able to fix the exact plane is unique to the Martin apparatus and thereby greatly increases the accuracy of the results obtained. These results are obtained without rotating, as it is merely necessary to turn the body to six or eight fixed positions, and, when actually balancing, no rotation takes place. The body's inertia does not affect this method, neither is there any question of an "angle of lag" upsetting the result.

On all built-up turbines, such as the Zoelly and Curtiss type, first the shaft and then each disc put on is successively balanced; the final balance obtained will then be without any disturbing couple, and many times more accurate than any result obtainable by existing methods.

In a drum-type turbine, such as the Parsons rotor, the overweight is taken out partly at each end in relation to the position of the centre of gravity. Reduction gear wheels can also be balanced by this machine. For propellers, fans, flywheels, rotary aero engine parts and similar bodies, which are of relatively large radial and small axial dimensions, a mandril (in itself balanced) to take such parts can be used on the machine. The machine could also be used for standardising rotary parts, such as aero-engine cylinders, &c.

Messrs. Yarrow & Co., of Scotstoun, after thoroughly investigating the matter, have now adopted one of these machines for their work. Similarly, the Royal Shipbuilding and Engineering Company, "De Schelde," of Flushing, Holland, well-known over here, are using such a machine with great satisfaction and various other firms are considering the adoption of the apparatus.

THE BALANCING OF ROTORS.

TO THE EDITOR OF ENGINEERING.

SIR,—In ENGINEERING of the 3rd inst. I noticed with interest that the Vibration Specialty Company, of Philadelphia, brought the question of balancing rotary bodies into prominence by giving us a description of a dynamic balancing test of an intermediate gear wheel on their rotary balancing machine at Messrs. Beardmore's. I would like to make a few remarks on this question of balancing which may be of interest to your readers, and tend to give us some more views on balancing.

Up till now static balancing of such bodies consisted of rolling them on levelled knife edges. The main objection to this was that a large body such as a 10-ton rotor showed a great "laziness" against rolling which had a correspondingly bad influence on the accuracy of the results obtainable. As a rule the limit of accuracy was reached when the centre of gravity of such a body had been brought to within 0·013 mm. to 0·019 mm. of the body's axis of revolution, or say to about within 0·0006 in. It was then necessary to revert to some method of dynamical balancing, as any effect due to incorrect disposition of the balance weights would set up a tilting couple under centrifugal action which would rock the rotor.

It follows that the less accurately the static balance was done the less accurate would be the dynamical balance, also "a body should be in static balance before it can be put in dynamic balance. The quality of the dynamic balance is based on the static balance and is good or bad dependent upon whether the static balance is well or poorly done."

Until lately it has always been very difficult to find the exact plane in which the resultant moment of the unbalanced forces acts. By any dynamical method of measurement there was always the question of "an angle of lag" to contend with and to be allowed for so as to get this plane.

A method has, however, been successfully in use the last three years on the Continent by which it is possible to find the exact amount of the resultant moment of the unbalanced forces in a statical way, *i.e.*, without the body revolving during observations, thus no inertia influences from the revolving body occur to disturb these readings. In this way a result is obtained about 25 times to 30 times more accurate than possible with the knife-edge rolling method. Not only that, but this method enables one also to find the plane very accurately in which this resultant moment of the unbalanced forces acts without there being any question of inaccuracy due to the angle of lag as no turning takes place.

A moment of ¼ in.-lb. can quite easily be detected, its plane of action located and compensated for. A 10-ton rotor can be so perfectly balanced that its centre of gravity can be brought to within 0·0005 mm., or say, 0·00002 of an inch from the axis of revolution of the body. At the same time it enables the tester to keep a permanent record of the amount of correction made. All this is done in a very simple and quick manner without reverting to the expensive and dangerous method of running the rotor at speed.

In the list given elsewhere with a description of the apparatus (see page 864) particulars will be noticed of eight turbine rotors varying from 2¼ tons to 9¼ tons balanced by this method. The moments corrected are shown in kg/cm. as well as the corresponding correction of the rotors' centre of gravity in mm.

The test made on a small 5-in. gyro wheel of 3 kg. only, shows in the same way the moment's correction of 54 milligrammes with the corresponding correction of centre of gravity of 0·0012 mm. or about 0·00005 in. The latter test was kindly made by Dr. Barr, of Glasgow University, for me to show the wide range of adaptability of the machine. In such discular-shaped bodies there is no question of couple influences, and balance so obtained is, therefore, practically perfect. All these rotors balanced by this method proved so satisfactory that no further dynamical balance proved necessary.

Some of these turbines were run at 15 per cent. to 20 per cent. above their normal running speed under steam at the moored trials with the line shafting disconnected, and the vessels in light condition when no vibration whatsoever was noticeable. This seems to go to prove the fact that it is the quality of statical balance which counts. Anyway we never considered it necessary even to try any further dynamical balancing on these rotors. I understand that every one of these have given entire satisfaction in service since.

In the case, however, where makers should wish to run a dynamic test as well, it ought to be quite a simple job to correct any further un-balance due to a residual couple. To do this the moment of unbalanced forces and the plane of action would first be recorded by the method referred to but not corrected. The turbine would then be run slowly under steam conditions and heated up to the usual running temperature. The turbine might be carried on springs at its bearing ends if necessary, and two sensitive recording instruments to record any vibrations fitted at these points. If this proved unpractical, the rotor would have to be put on bearings as Mr. King Salter showed us in his lecture at the last April N.A. meeting, and the "Stiction" measured, or as Professor H. Wilda showed in his book of steam turbines, Part II, 1914.

To proceed, we now know the resultant moment of the unbalanced forces and its plane of action from the static method shown. If we then fix in this plane at each end of the shaft a moment and arrange that the sum of these moments is always equal to the given resultant we will only have to alter these moments (keeping their sum equal however) until there is no noticeable rock in the shaft. These moments can either be both at the same side of the shaft, or dynamically opposed always lying in the given plane. A few spins ought to give the required data.

Practically speaking, any residual couple which may remain in a built-up rotor, of which first the shaft and then every disc, as it is put on, has been successively so balanced, is negligible. This is, no doubt, why in all the above rotors no better balance was ever needed or seemed obtainable.

Trusting not to have encroached too much on your valuable space, and hoping this may lead to further contributions on this interesting question of balancing.

Yours faithfully,

W. H. MARTIN, A.M.I.N.A.

Empire Works, 58, Harleyford-road, Vauxhall, S.E. 11.
December 15, 1920.

ESTIMATION OF SULPHUR BY THE LAMP METHOD.—The sulphur percentage in oils and motor fuels is best determined by combustion of the oil with oxygen at a pressure which need not exceed 10 atmospheres in a Mahler bomb, in which all the sulphur, no matter in what state of combination, is oxidised. When high accuracy is not required, more convenient lamp methods may be used. The oil, dissolved in or diluted with some spirit free of sulphur, is burnt in the wick of a lamp and the products of combustion are passed through an absorption apparatus containing sodium carbonate. A new form of lamp for this purpose was brought before the Institute of Petroleum Technologists by Mr. F. Esling, A.I.C., on Tuesday, December 14. The lamp is made entirely of glass, the stopper, through which the wick passes, being ground in. The absorption apparatus contains some glass wool. Mr. Esling acknowledged that the alkalinity of the glass wool had given him trouble. Dr. Dunstan, who read the paper in his absence, said that he replaced the glass wool by fine capillary tubes of hard Jena glass; Dr. Ormanby stated that he considered all glass objectionable on account of alkalinity, and would use quartz alone. Mr. Esling recommends his lamp only for light oils, because heavy asphaltic oils are retained by the wick; his sulphur percentages were decidedly lower than the bomb values. The question is, however, whether the wick does not always exert a selective absorption effect on the sulphur compounds in the oil, and there is, further, danger with burning wicks that they may introduce nitrogen oxides into the gases which when the acidity is determined by titration with a colour indicator, would be counted as sulphuric acid. It is, moreover, doubtful whether the lamp yields the sulphur as SO_2 or as SO_3. Gravimetric estimation of the sulphuric acid is preferable to volumetric estimation.

THE "MOS" TELESCOPIC-MAST CRANE.

The illustrations, Figs. 1 to 6 on page 868, show a type of crane, known as the Mos crane, the first example of which has recently been introduced into this country, although the design has been employed for several years on the Continent, especially in Belgium. The first Mos crane, it may be of interest to mention, was used some fourteen years ago in the construction of the now-famous Zeebrugge Mole. The crane is particularly useful for building construction and other similar purposes, in that besides enabling high lifts to be obtained, it can be erected easily and quickly, and afterwards removed and re-erected elsewhere as one contract is completed and another commenced. The advantage of this feature in comparison with the three-legged timber staging and Scotch derrick usually employed in the construction of large buildings will be apparent when the method of erecting the Mos crane has been explained later in this article.

In this country the crane is supplied by Messrs. Builders' and Contractors' Plant, Limited, 15, Victoria-street, Westminster, London, S.W. 1, and the one above referred to is, at present being used in the construction of a wharf at Stepney for Messrs. T. Hubbock & Son, Limited, and Messrs. Batger & Co. Later it will be employed in the erection of warehouses for these firms on adjoining sites. The crane was supplied to the order of the contractor, Mr. J. E. Whiter, after having been approved by Mr. Harold Cane, who is consulting engineer for the work. The general arrangement of the crane is shown in Figs. 2 and 3, which also give its main dimensions. Fig. 1, which shows the method of erection, will be referred to subsequently.

As will be seen, it is of the travelling-pedestal type, with a revolving and elevating mast, and a jib giving a maximum lifting radius of 30 ft. and a minimum radius of 16 ft. 4 in. At the latter radius the crane can handle a load of three tons, and the maximum height of the centre of the pulley is 85 ft., while at 30 ft. radius, the maximum load is 1½ tons and the maximum height of the pulley for this radius is 66 ft. The lifting capacities just given, however, are those with the crane merely resting on the rails, stability being dependent upon the weight of the structure and the ballast with which large tanks on the pedestal are filled. By clamping the crane down to the running rails, however, a load of 4½ tons can be handled at the minimum radius. The pedestal, which is 9 ft. 10 in. square in plan and is constructed of steel plates and sections, is 4 ft. 9⅛ in. high, and runs on rails laid at a distance of 8 ft. 2⅛ in. apart, centre to centre. Its construction is best shown in Figs. 4, 5 and 6, which also show the arrangement of the hoisting machinery and the method of driving the travelling wheels. The latter, it will be seen, are carried in castings on each leg of the pedestal and are driven by vertical shafts through bevel and spur gearing. A special feature of the design, which may be referred to here, is the arrangement which permits the wheels to be turned round by hand so that the crane can be moved on to another track at right angles, or at any other angle, to the track on which it was originally working, without the use of turntables. For this purpose the running wheels, as stated above, are mounted in castings, which, when the legs are jacked up one at a time, can be turned round by hand about a vertical axis, the double flanges on the wheels being made in removable sections to enable this to be done.

Above the pedestal is a rectangular steel framework, 12 ft. high, enclosing the machinery and operating platform, and supporting a braced structure which acts as a guide and support for the mast. The latter structure is 3 ft. 4 in. square in plan, and 28 ft. 2 in. high. In it the elevating mast is housed, the lower end of the mast being carried by a footstep bearing in a table which slides inside the framework. The mast, which is a forged and swaged steel tube, is 12½⅛ in. in diameter externally for the greater part of its length, but its diameter is decreased in steps near its upper end, as shown in Fig. 2. At the upper end of the framework guide, the mast passes through the centre of a toothed casting which gears with a pinion on a vertical shaft running from the machinery platform, and is used for the slewing motion; a complete revolution takes about 1½ min. Set screws are used to transmit the motion of the toothed casting to the mast, and these must, of course, be slacked back when the mast has to be raised or lowered. This arrangement has the advantage that it renders it less likely for the mast to be raised with the load on. The vertical movement of the mast is effected by means of two wire ropes which pass round a separate drum on the machinery platform up to pulleys at the top of the framework, down to pulleys on the table carrying the lower end of the mast, and up again to fixed points near the top of the framework. In this way a double-purchase lift is obtained. It should be explained, however, that the table carrying the lower end of the mast is clamped to the framework when the mast is in the required position, so that the wire ropes are relieved of the load.

The jib consists of a steel tubular boom with a maximum diameter of $8\frac{5}{16}$ in. It is supported by means of wire ropes passing over pulley blocks as shown in Fig. 2, and luffing is usually effected by hand; in the case of the crane at Stepney, however, a separate 3 h.p. motor and winding drum have been fitted for this purpose. The wire rope from the main hoisting drum passes up through the mast over a pulley at the upper end, to another on the end of the jib and down to the hoisting block as will be clear from Fig. 2. The hoisting speed is 130 ft. per minute. All the motions of the crane, except that of luffing above referred to, are operated by a single motor of 15 h.p., which always runs in the same direction. This motor drives the pulley on the extreme left of Fig. 4 by means of a belt, and the motion is transmitted to the main hoisting drum and mast-elevating drum by means of spur gearing, which also enables the direction of rotation of the drums to be reversed for lowering. The two drums are put into gear by means of friction clutches, and clutches are also used for the reverse gear. The travelling speed of the crane is 90 ft. per minute, and the method of operating the travelling motion is indicated in Fig. 6, which is a plan of the top of the pedestal taken under the hoisting and mast-elevating machinery. The short shaft, lettered *a*, which is driven by a roller chain from one of the slow-speed shafts of the hoisting mechanism, drives the shaft *b*, through a pair of mitre gears and friction clutches, so that the direction of rotation of *b* can be reversed at will by putting either of the clutches into gear. Parallel with the shaft *b*, and connected to it by roller chains, are two side shafts, which drive the travelling wheels by bevel and spur gearing which will be clear from Figs. 4 and 6. The chain sprockets for this motion can, however, be disconnected from the shaft, *b*, by means of a dog clutch, and the shaft can then be used for driving the vertical shaft for the slewing motion. This is put into gear by the dog clutch at the end of shaft, *b*, but the gear itself is not shown. The clutches for all the motions are operated by foot pedals, or handwheels, by the driver without changing his position.

In a crane designed for the class of work for which the Mos crane is intended, the questions of transport and erection must be carefully considered. For transport, the Mos crane can be divided into three main parts, the pedestal, the rectangular framework above it, and the mast support, mast and jib. The heaviest part is, of course, the pedestal which weighs 6½ tons with the machinery, but without ballast. It can, however, be handled by a steam wagon, and the transport of the other parts presents no particular difficulty. The total weight of the crane is 15½ tons. In erecting the crane the method adopted naturally depends, to some extent, on the room available, but Fig. 1 illustrates the usual procedure, and this method was employed for erecting the crane at Stepney. The pedestal is placed in position with its wheels scotched and steel sheerlegs, supplied with the crane, and lettered S in Fig. 1, are fitted up as shown. The sheerlegs are pivoted to the pedestal and supported by a single wire rope T, attached to its upper end and to a stake driven into the ground. The two upper parts of the crane are connected together in the horizontal position and pivoted to one side of the pedestal, as shown, and a wire rope, U, is taken from the main hoisting drum of the crane round a snatch block on the stake, over a pulley on top of the sheerlegs to another pulley near the upper end of the crane structure, and back again to the sheerlegs, to which it is secured. Winding in the rope, U, by the crane's own power thus pulls the upper part of the structure into the vertical position, the time required for this part of the operation being only about 15 min. A load of about one ton is suspended from the jib during the process of erection in such a manner that its effect is felt only in the latter part of the lift. This keeps the luffing ropes taut, and also tends to equalise the pull in the rope, U, which would otherwise slacken off as the structure became nearly vertical. When the vertical position is reached, the two legs of the upper structure are bolted to the pedestal, and the mast support adjusted by means of the turnbuckle stays shown in Fig. 2. As soon as the hoisting rope, slewing motion and mast elevating gear have been connected up, an operation which takes about an hour, the crane is ready for work. The whole operation of getting the crane to work would take about a day from the time it was delivered on to the site.

A crane of the type described above could be mounted on a timber gantry, and could travel right round a large building in a busy thoroughfare, or it could of course, be worked from the centre of the building. The chief advantages claimed for it in building work are the rapidity and cheapness with which it can be erected and dismantled, and the saving in space effected by the absence of timber towers. It would also, however, appear to be quite suitable for other classes of constructional work, as well as for use as a wharf or warehouse crane.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The current stoppage at engineering and steel works will be of longer duration than usual. This is primarily due to the falling off in purchases on both home and export account, but is also necessitated by an exceptionally large number of repairs required to be done to heavy plant and machinery. Some of the steel melting furnaces have already been idle a fortnight, and will not resume for a similar period. In some of the finished sections where prosperity is more stable, notably in the case of tool manufacture, preparations for resumption will be made this week, but in the majority of instances a start will not be made until the new year. Exaggerated reports are in circulation as to the extent of unemployment among steel-workers. Official statistics show that the actual total discharged does not exceed 5,000, which scarcely equals the normal average of pre-war times. While it is true that the steady depletion of orders has given rise to anxiety the local position appears to be fairly sound at heart. Producers of raw and semi-finished materials are pretty heavily hit by the increasing importation of cheaper products from abroad, and an attempt has been made to adjust local rates so as to reduce the margin of difference. On the other hand, the accessibility of lower-priced materials is not unattractive to makers of tools and machinery, who are thus able to cut production costs. Plenty of work remains to be done in castings and forgings, though there is a decided falling off in the call on shipbuilding account, and for materials required by the motor-car industry. Farm tools, mining implements, and joiners' requisites are in steady request. Armament makers have more work on hand than is represented by the few contracts publicly notified for the Japanese and Dutch Governments. The slump in tool steels and steel alloys is unrelieved, and is accompanied by a further fall in quotations.

South Yorkshire Coal Trade.—The decision to allow a certain amount of large coal to be sent for export to the Humber ports, providing it is sold with a proportion of slack, is welcomed by the trade of this district. The arrangement is to come into force at once, but is experimental, and is subject to inland supplies being properly met. Collieries, however, have no doubt of their ability to meet home requirements to the full. If the increase in production continues at the rate recently experienced, and the wagon service is ample, there should be a fair margin for export. On the whole, steel works, gas concerns, and public utility undertakings are well stocked pending a resumption of coal getting. The renewed demand for house-coal has made a big hole in reserves at depots, which will require augmenting as soon as business resumes its normal swing. Quotations: Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—As is customary at this period of the year, business is at a standstill, holiday making being general. Cleveland foundry pig is still very scarce, but stringency has been relieved by the closing down of consuming works for the holidays. So far as can be ascertained resumption of foreign business has not followed the removal of the ban on export of foundry quality, and it is admitted that export sales cannot be looked for at present prices, which are much above what Continental customers are prepared to pay. As yet, however, home needs take up the whole of the output of foundry pig. To home customers No. 1 is 237*s.* 6*d.*; and No. 3 is 225*s.* The inferior grades are very plentiful, but producers still refuse to make price concessions for forge, mottled and white, all of which are put at the same figure as No. 3.

Hematite.—A distinctly easier feeling prevails in East Coast hematite, and as cost of production is coming down, lower prices for iron are confidently anticipated. There is no foreign demand for hematite. For home purposes No. 1 is 262*s.* 6*d.*; and Nos. 2 and 3 are 260*s.*

Foreign Ore.—There is little or nothing passing in foreign ore. Consumers are fairly well placed, and are not in the market to buy just now, as further fall in values is threatened. The ex-ship Tees value of best rubio is certainly no more than 49*s.*

Coke.—Plentiful supplies of coke have enabled local consumers to replenish stocks, and they are now looking forward to cheaper prices. Sellers, however, report that they are still able to realise 62*s.* 9*d.* at the ovens for medium blast furnace kinds, and 65*s.* 3*d.* at the ovens for quality low in phosphorus.

Manufactured Iron and Steel.—There is little or nothing passing in finished iron and steel, traders awaiting the revision of prices promised early in the new year. Works are shut down, and some firms are taking a longer holiday than is customary at Christmas. The following are among the principal market quotations: Common

iron bars, 27*l.* 10*s.*; steel ship, bridge, and tank plates, 24*l.* 10*s.*; steel ship angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; soft billets, 22*l.*; medium billets, 23*l.*; hard billets, 24*l.*; heavy steel rails, 25*l.*; and fish plates 30*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—Time was when exceptionally active conditions ruled during the last months of the year, and when an extra spurt was necessary to fulfil many promises of delivery before closing down for the holidays, but things have a very different complexion this year, and pressure for supplies is almost entirely absent. One or two industries in the country are better placed, but the vast majority are all bemoaning the poor demand for material. In the latter category must be included the iron and steel trades, where business is very flat. Several establishments finished operations for the year at the end of last week, and now many furnaces and mills have been closed down and will not be restarted until about the middle of January. Inquiries generally are not numerous, and although all of these are being diligently followed up, the result is not satisfactory, as buyers will not place their orders under present price conditions, preferring to hold off as long as possible so as to get the benefit of any fall in price which may come into force in the near future, which is openly expected. A further point which buyers are making is that the reduction which they are anticipating must be a substantial one before they will be induced to enter the market. The engineering trade is very quiet at present, but several branches of it have still just as much work on hand as will keep them going full for some months yet. The makers of sugar machinery are in that class as most of them are very well booked forward. General export trade is poor and the exchange and money market has much to do with that. The year 1920, which opened so full of promise, is closing in rather a disappointing manner, and with the prospects for 1921 slightly cloudy.

Scotch Steel Trade.—The Scotch steel trade has been slowing down lately and the demand has fallen away considerably. A fair amount of stuff has certainly been going out, but most of it has been for immediate requirements, as consumers decline to stock anything beyond their actual needs at the present time. Ship and boiler plates are fair, but in the case of structural sections there is extremely little doing, and prices are easier, but even with that Continental sections are being offered much lower. Galvanised sheets are decidedly off in the meantime, and even black sheet makers are complaining of a lull in trade. A fair amount of business is still on hand, but little is being booked to take the place of what is being turned out. The export trade all round is exceedingly quiet, and very little material is being shipped.

Malleable Iron Trade.—The position in the malleable iron trade of the West of Scotland shows little alteration, and a dull time would seem to be coming. Makers are not so badly off for the present, but with buyers holding off it is the near future which gives managements some concern. With "crown" bars called 27*l.* 10*s.* per ton, there is little fresh business, and if this figure is to be much reduced certain economies will have to be practised at the source of production.

Scotch Pig-Iron Trade.—No change of any kind falls to be noted in the pig-iron trade of Scotland, and the demand is just about parallel with the present-day output. The latter is on quite a small scale and is going rapidly into consumption, and no stocks are held. Consumers are managing to secure sufficient to keep them going, and in no case are they very desirous of accumulating stock for fear of prices easing off with the beginning of the year. Foundry iron continues scarce and is in quite good demand, and hematite is being readily taken up by steelmakers. Export trade is almost a dead letter at the present time.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The efforts made by the extremists' section in the past week to create trouble in the South Wales coalfield have proved abortive and, for the time being at least, the menace of a general strike has been averted. The trouble over which an endeavour was made to make capital was the dismissal of 11 workmen at the Parc colliery of the Ocean Coal Company. These men had been given notice to terminate contracts owing to their working places having become absolutely unremunerative. As a sequel the whole of the Rhondda miners, numbering about 45,000, struck work on the eve of the holidays and the programme was to convene a delegate conference of the South Wales Miners' Federation in order to adopt a down tools policy throughout the coalfield. Although less than a dozen men were immediately involved, and even these were offered work at other pits under the same company, the issue raised was really of vital importance. As a matter of fact it was tantamount to a challenge to colliery companies and managements as to the extent of their right to control and manage their undertakings on economic lines. When the responsible leaders of the Federation met at Cardiff they discountenanced the idea of calling a conference and requested the men to return to work pending an effort to effect a settlement of the trouble. It was evidently realised that the management of the Parc colliery had pursued a reasonable policy in dispensing with the men who did not give a return for the wages paid them, and at one time the outlook was threatening and there appeared every indication that the issue would have to be fought out. Fortunately wiser counsels have prevailed and the probabilities are that an agreement will be arrived at in the course of a week or so. It may be added that the possibility of strife over the matter is not yet completely removed, and developments are awaited with considerable interest and some anxiety. Meanwhile holiday conditions have pervaded the coal market. On the whole buyers are adopting a hold-off policy, and though prices are already much below those ruling a month ago, it is anticipated that they will fall still further. The loss of output occasioned by the Rhondda strike had practically no effect on prices for Monmouthshire coals were freely available, while the fact that the stoppage occurred on the eve of the holidays prevented shippers affected by the stoppage from substituting other coals to any large extent. Best Admiralty large coals are now obtainable at 85*s.*, and Monmouthshire 75*s.*, while best steam smalls are round 60*s.*, with inferior grades from 45*s.* These prices are at least 20*s.* per ton below those commanded a month ago. Coke and patent fuel are also easier. In fact there is practically no demand for these commodities, and prices in the circumstances are nominal. Foreign cargo exports of coal from South Wales in the past week totalled 265,000 tons, compared with 358,000 tons in the preceding six days.

CASTOR OIL.—From Bulletin 867, drawn up by J. H. Shrader, of the United States Department of Agriculture, we see that the normal annual consumption of castor oil in the United States exceeds 2,000,000 gallons, nearly all manufactured locally from imported seed. Up to 1917 the average imports of castor seed amounted to 834,000 bushels (of 46 lb.), of which India supplied 60 per cent. and the West Indies 8 per cent. In 1917-18 the imports of castor oil rose to 1,250,000 bushels, and the cultivation of the rhicinus plant yielding the seed, which had quite dropped out since 1900, was resumed in some of the States; whether the cultivation will be persisted in, is doubtful.

ARC-WELDING OF TRAMWAY RAILS.—A simple method of joining tramway rails has since 1919 found adoption on some German lines, notably in Leipzig, Halle, Munich and Cologne. The method does not require thermit, or moulds or special fish-plates. The usual fish-plates are welded to the foot and the head of the rails, but they are inverted so that the larger flange bears against the top and the smaller flange against the foot of the rails. The welding is effected by means of the electric arc and rods of iron; the molten iron welds the flanges to the rails, the large flange—turned upward as mentioned—preventing the fused metal from dropping off. The operation requires very little time; the upper surface of the rail does not get red hot, and the rail foot does not fuse. Defects in rails are also made good with the aid of the arc. The process, which is due to the firm of Ingrer, Block and Co., of Berlin, has now been applied for more than a year.

ACTION OF CHLORINE ON WATER.—The discussion on "The Sterilisation of Water by Chlorine," held by the Institution of Mechanical Engineers (see ENGINEERING, November 26, page 694), probably left engineers with the impression that the action of chlorine on water is not really understood. Chemists will admit that, though the problem has certainly not been neglected. When chlorine is passed into water, in the absence of other reagents and of light, the reaction $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$ is believed slowly to proceed to an equilibrium condition—that is to say, hypochlorous acid and hydrochloric acid are produced until a certain acidity is reached, when the two acids combine again under reformation of chlorine and water. The decomposition of the HOCl is hastened by the action of light. These reactions, however, are by no means the only ones possible. Some chlorine seems to be bound by the water in the form of a hydrate. At higher temperatures chloric acid is produced. The old-established Deacon process is based upon the fact that at temperatures of about 500 deg. C., and in the presence of certain catalysts, *e.g.*, bricks impregnated with copper chloride, chlorine and steam yield hydrochloric acid and oxygen. The reversal of this process for the production of chlorine is now also under investigation. That iron acts as a catalyst in the ordinary chlorine-water reaction at ordinary temperature is doubted by George L. Clark and R. B. Iseley, of Nashville University (*Journal of Industrial and Engineering Chemistry*, November, pages 1116 to 1122). They enclosed chlorine and water in bottles, kept in the light or dark, and analysed the water after intervals of up to 100 hours. They found that the HCl percentage became constant after about forty-eight hours, and they suggest that chlorine is actually bound by water and cannot, in that state, be expelled again by bubbling air through the water. Similarly, when iron is present ferrous chloride is said to be formed as the HOCl disappears, but again the reaction, *i.e.*, the corrosion of the iron, stops when a certain amount of HCl has been formed. In their rusting tests Clark and Iseley enclosed steel foil with chlorine and water—river water, reservoir water (river water treated with alum) and distilled water—in bottles, and they observed that the order of the corrosion was that given, *i.e.*, the distilled water corroded the steel most, for equal percentages of chlorine. These rusting tests are hardly conclusive, of course, and the paper quoted is chiefly interesting for the details given of the difficult analysis of chlorine water. One would like to learn more about the possibility of binding the chlorine by the water so as to stabilise the solution.

NOTICES OF MEETINGS.

ROYAL SOCIETY OF ARTS.—Monday, January 3, at 5 p.m. (Colonial Section). Fred C. Cornell, O.B.E., "The Alluvial Diamondiferous Deposits of South and South-West Africa." Major Sir Humphrey Leggett, R.E., D.S.O., in the chair. Thursday, January 6, at 3 p.m. (Juvenile lecture). Sir Frederick Bridge, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, "The Cries of London which Children Heard in Shakespeare's Time."

INSTITUTION OF AUTOMOBILE ENGINEERS.—Wolverhampton Centre. Tuesday, January 4, 7.30 p.m., a paper will be read by Mr. H. Stevens on "The Problems of a Designer and How they Affect Production."

ROYAL INSTITUTION OF GREAT BRITAIN.—Christmas lectures: "The Haunts of Life," by Professor J. Arthur Thomson, M.A., LL.D.: Lecture III, Tuesday, January 4 "The Great Deeps"; Lecture IV, Thursday, January 6, "The Freshwaters"; Lecture V, Saturday, January 8, "The Conquest of the Land"; Lecture VI, Tuesday, January 11, "The Mastery of the Air"; at 3 o'clock.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 7, at Caxton Hall, at 8 p.m., lecturette "The Indicator: its Use and Application," by H. G. Pusey (Member).

INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, January 8, 1921, in the College of Technology, Manchester, to commence at 4 p.m., when Mr. S. Hurst, of Radcliffe, will open a discussion on "Hard Castings in the Machine Shop." After the meeting the annual dinner will be held in the Albion Hotel, Piccadilly, Manchester, at 6.30 p.m.

PERSONAL.—Mr. John Ames, General Secretary of the Industrial League and Council, has been appointed a member of the Commercial Panel of the Appointments Department of the Ministry of Labour.—Messrs. Kincaid, Walter, Manville and Dawson inform us that they are now re-instated in their offices, St. Stephen's House, Victoria Embankment, Westminster, S.W. 1, which were commandeered by the Government during the war. They also advise us that they have taken into partnership Mr. A. E. Jackson, M.Inst.E.E., and Mr. H. G. Simmonds, who have been intimately associated with them as their principal assistants for many years past. There will be no alteration in the style or title of the firm.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.—Lectures on Meteorology. Arrangements have been made for the following courses of lectures on meteorology at South Kensington:—Mr. C. T. R. Wilson, F.R.S., ten lectures on Atmospheric Electricity commencing January 12; Captain D. Brunt, a course of lectures on Dynamical Meteorology, commencing on January 11; Sir Napier Shaw and Miss Austin, continuation of the course on Instruments and Methods, commencing January 17 (daily work on weather maps is arranged with this course); Sir Napier Shaw, a course for the University of London on an Historical Review of Meteorological Theory, commencing January 21. The fees, &c., may be ascertained by communicating with the Registrar, Imperial College, South Kensington, S.W. 7.

A BIRMINGHAM ENGINEERS' CLUB.—For some time past an influential committee has been working in Birmingham with the object of providing a club in the district, where engineers can meet both for business and socially. Such progress has now been made that an option has been exercised on premises in the centre of the city, names of prospective members and promises to subscribe capital are being received, and the project is receiving hearty support from many of the leading industrial and professional men in the Midlands. The president is Sir Hallewell Rogers, chairman of the Birmingham Small Arms Company, while Dr. Garrard, of the General Electric Company, is the chairman of the general committee. Mr. J. Fearn, of the Birmingham Small Arms Company, is acting as hon. secretary. It is intended that there shall be no entrance fee for the first 500 members, and the subscription is to be five guineas per annum. For members residing at a greater distance than 50 miles from Birmingham the subscription will be two and a-half guineas. We are glad to commend this project to our readers.

CORROSION OF STEEL IN THE PRESENCE OF COPPER, MANGANESE AND CHROMIUM.—In a paper on "The Influence of Copper, Manganese and Chromium and Some of their Combinations in the Corrosion of Iron and Steel," by Messrs. E. A. Richardson and L. T. Richardson, delivered before the general meeting of the American Electrochemical Society in Cleveland, Ohio, on September 29 and October 1 and 2, the following conclusions were reached, according to *The Iron Age*, New York: It has been shown that there is a mutual action between manganese and copper in their effect upon the atmospheric corrosion of iron. Copper alone reduces the corrosion of pure iron and to a still greater extent, the corrosion of steel. This is due to the manganese in the steel enhancing the effect of copper. If manganese is replaced by chromium the effect is still more pronounced. It is shown that the red-short range in iron, due to the presence of copper, is removed by either manganese or chromium. It is believed that there is some relation between this red-short range and resistance to atmospheric corrosion. Based upon this, the film or intergrain hypothesis is suggested to explain the corrosion resistance of these alloys.

THE "MOS" TELESCOPIC MAST CRANE FOR BUILDING CONSTRUCTION.

(*For Description, see Page* 866.)

Fig. 1.

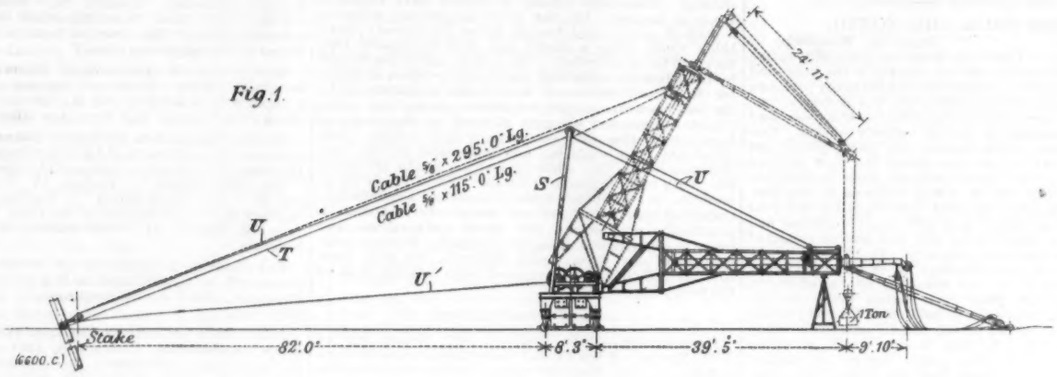


Fig. 2.

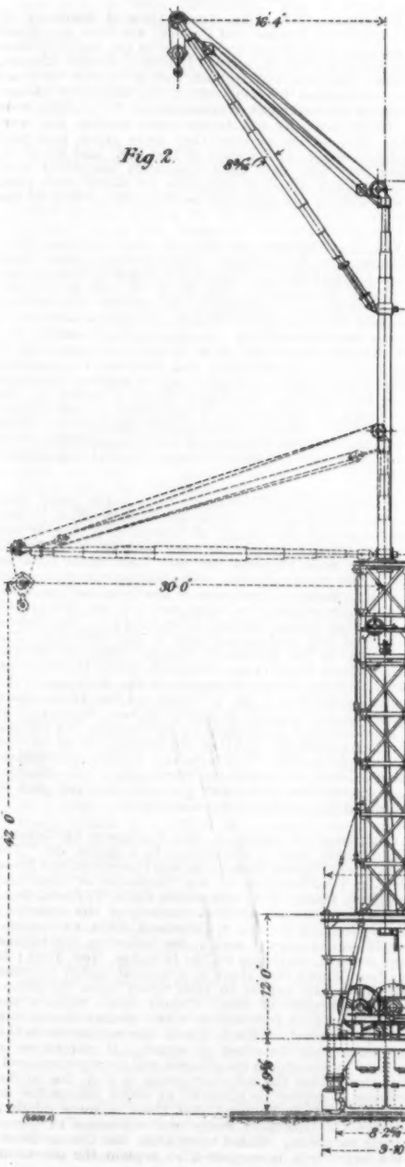


Fig. 3.

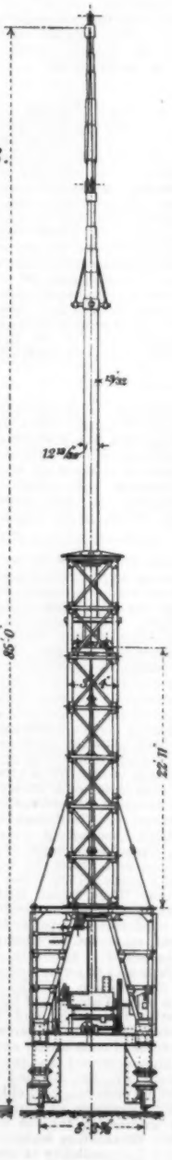


Fig. 4.

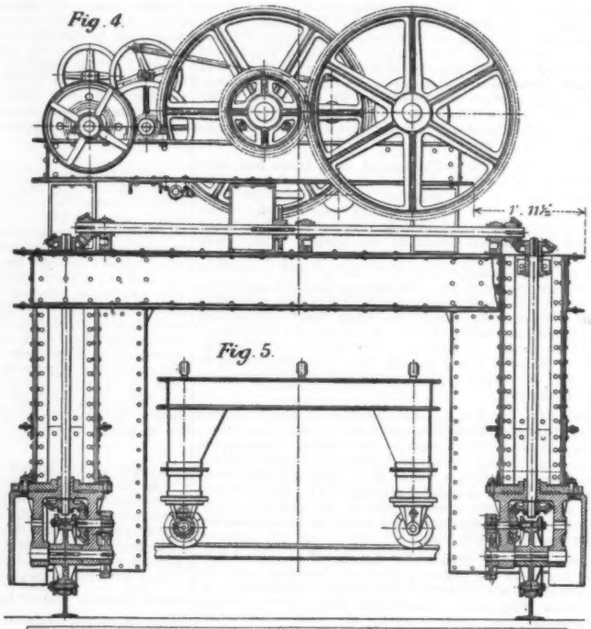
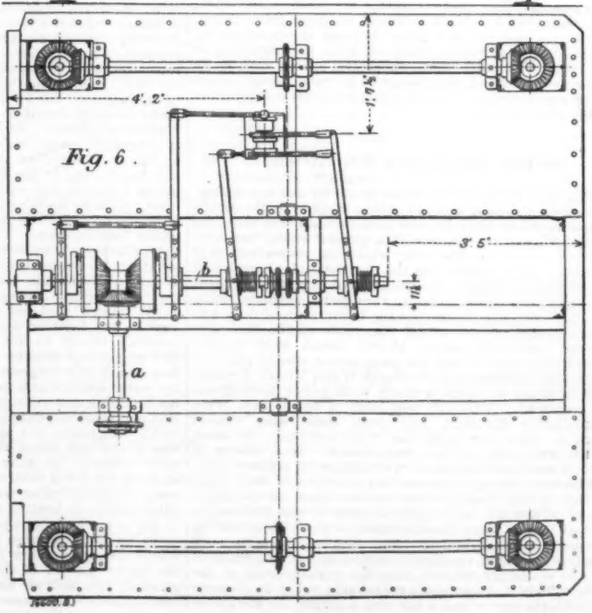


Fig. 5.

Fig. 6.



DETAILS OF THE SIX-CYLIN

CONSTRUCTED BY THE SOCIÉTÉ ANONYME MINERVA

(For Description, see Page

Fig. 1.

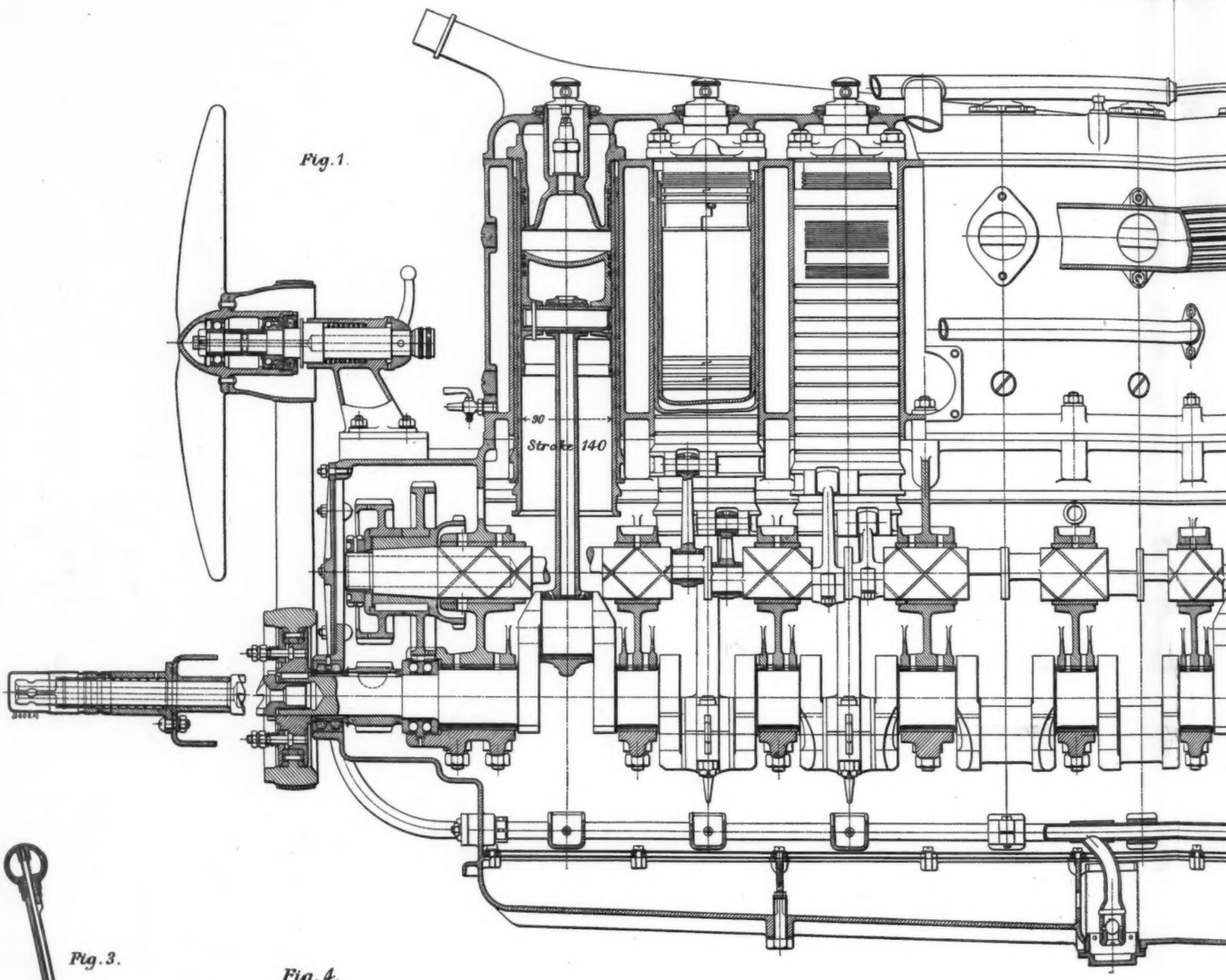


Fig. 3.

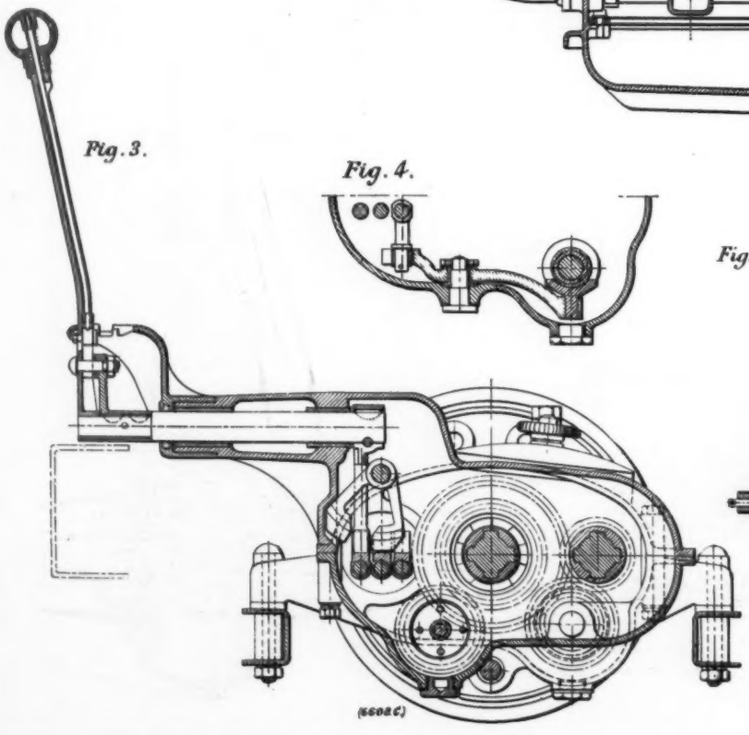


Fig. 4.

Fig. 5.

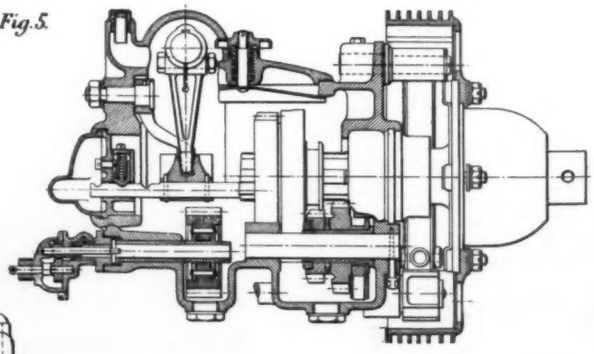
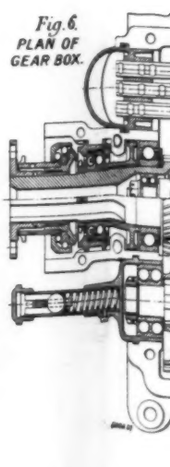


Fig. 6.
PLAN OF GEAR BOX.



-CYLINDER MINERVA CAR.

ME MINERVA MOTORS, ENGINEERS, ANTWERP.

ription, see Page 862.)

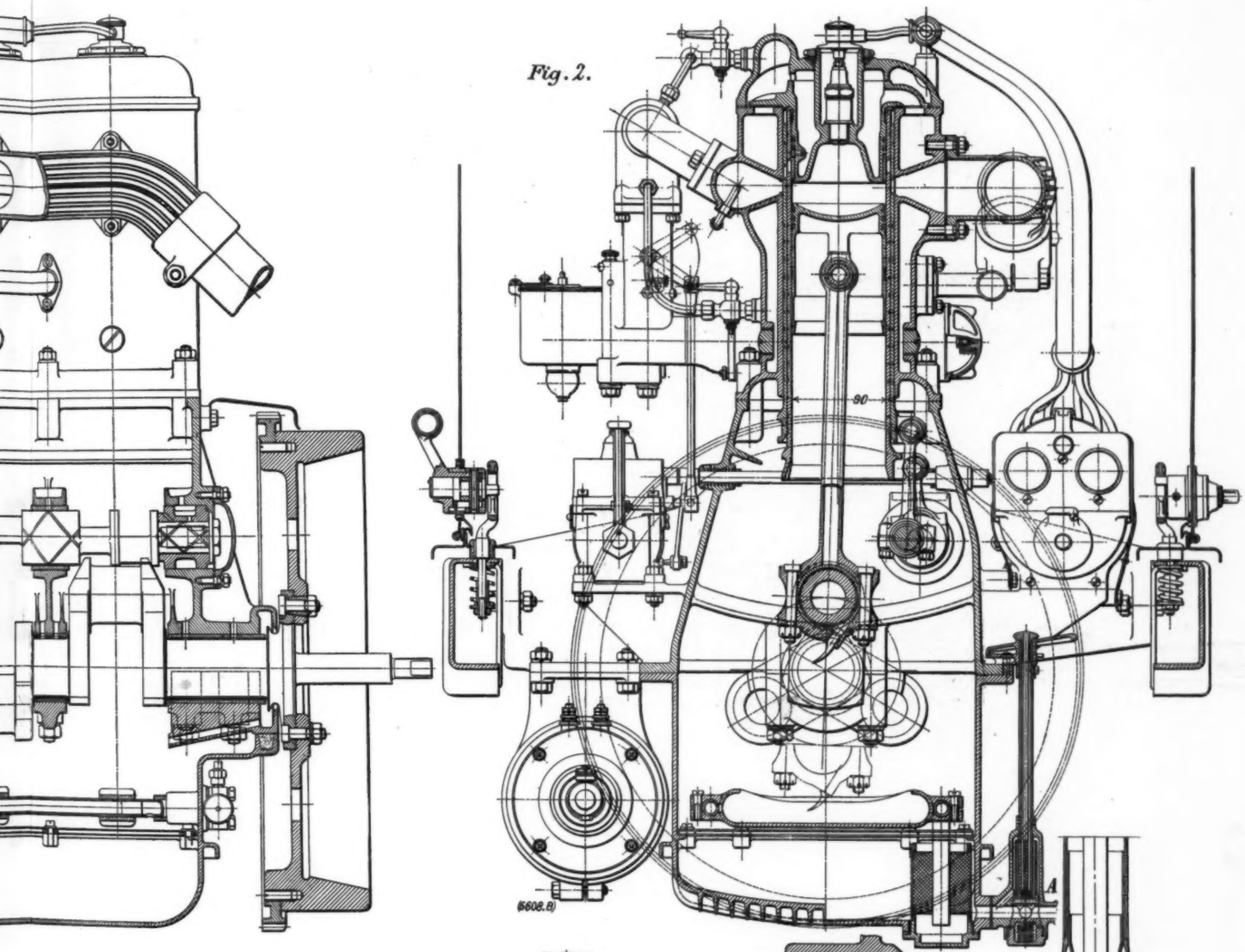


Fig. 2.

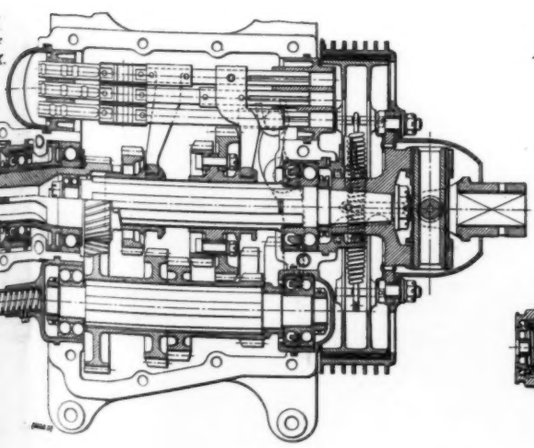


Fig. 7.

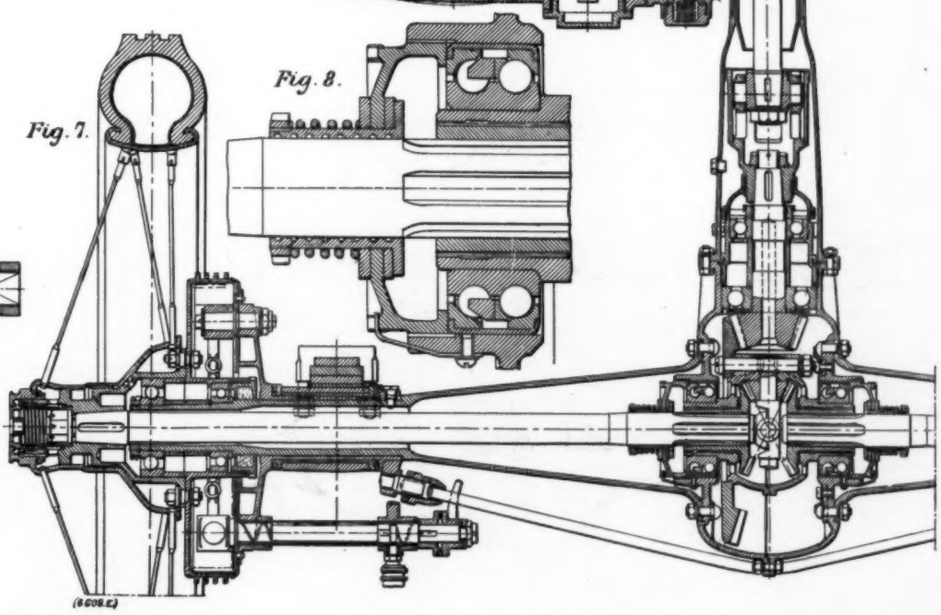


Fig. 8.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm Dawson and Sons, Manning Chambers.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co., Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long Street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements, J. S. Allan, 30, Church-street, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisments, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick ,, ,,	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick ,, ,,	£3	7	6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3683 and 8598 GERRARD.

CONTENTS.

	PAGE
The Thermal Equilibrium of Refrigerating Plants (*Illus.*)	853
Defects in Motor Vehicles and their Remedy	855
Wells and the Permeability of Soils (*Illus.*)	856
Goods at Owner's Risk	857
Interferometer for Testing Optical Systems (*Illus.*)	857
Vertical Tandem Gas Engines (*Illus.*)	861
The Six-Cylinder Minerva Car (*Illus.*)	862
Industrial Notes	862
Notes on New Books	863
Year-Books and Annuals	863
Cold-Storage Boats "Rhenania 13 and 14"	863
The late Mr. John George Valentine Mair-Rumley	864
The Martin Rotor Balancing Apparatus (*Illus.*)	864
The Balancing of Rotors	865
The "Mos" Telescopic Mast Crane (*Illus.*)	866
Notes from South Yorkshire	866
Notes from Cleveland and the Northern Counties	866
Notes from the North	867
Notes from the South-West	867
Notices of Meetings	867
Lubrication	869
Railway Rates	870
The Artificial Lighting of Interiors	871
Two Revolutions in Naval Warfare	871
Notes	873
Literature	873
Books Received	875
Diagrams showing Fluctuations in the Prices of Metals from Christmas, 1919, to Christmas, 1920	876
Radiology Applied to the Testing of Materials (*Illus.*)	877
Some Reflections on our Industrial Situation (*Illus.*)	879
Some Features in the Behaviour of Beta Brass when Cold-Rolled (*Illus.*)	882
ENGINEERING Patent Record (*Illus.*)	885

With a Two-Page Plate of the DETAILS OF THE SIX-CYLINDER MINERVA CAR.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 867.

ENGINEERING.

FRIDAY, DECEMBER 31, 1920.

LUBRICATION.

THE literature devoted to the subject of lubrication is remarkably extensive. Experimental investigations which started with Coulomb in 1781, have been continued ever since, and vast sums have been expended by our railway companies, who use some 60,000 tons of oil per year, and by lubricant manufacturers, in the endeavour to discover the real nature of the difference between good and bad lubricants. Numerous researches have also been carried out by private workers, but the outcome has been singularly disappointing, and when the Lubricants and Lubrication Inquiry Committee was appointed in 1917, Osborne Reynolds' papers of 1884 and 1886, which originated in Beauchamp Tower's experiments made for the Institution of Mechanical Engineers, constituted the only research of fundamental importance. Beauchamp Tower, moreover, stands head and shoulders above any previous investigator of the subject on the experimental side, and it was his close observation which detected the eccentricity of the journal in its brass and thus provided the basis on which the keen insight of Reynolds founded the hydro-dynamical theory.

In these papers of Reynolds we were given for the first time a glimpse into the character of the mechanism involved in lubrication, and some accord was at last established between the physical properties of a fluid and its lubricating value. In this connection reference may perhaps be made to the preposterous claims of Petroff to have anticipated Reynolds. A study of Petroff's papers shows that much the most valuable work effected, by this investigator was the discovery of one or two unimportant errors of sign in some of the terms of the expansion used by Reynolds in calculating the distribution of pressure in the oil film surrounding a rotating journal. The intrinsic value of his work is easily deduced from this fact. The fundamental concept that lubrication was associated with the viscous flow of the lubricant and failed when the flow became turbulent is nowhere foreshadowed in Petroff's papers. We make this observation here because Petroff's claims have been more or less admitted without due investigation by certain British writers on lubrication. Reynolds' work, though fundamental, was directly applicable, however, to bearings running in conditions which were at the time somewhat exceptional, and are still very far from being the rule. He showed that when the supply of lubricant was very ample the sole physical property of importance was the viscosity of the lubricant, and all subsequent experience has confirmed this conclusion. Thus molasses, which is not generally recognised as a lubricant at all, works quite satisfactorily if Reynolds' conditions are fulfilled.

For one bearing, however, which is running under conditions in which the lubrication is "complete," there are scores which are worked with scanty and intermittent supplies of lubricant, and when this is the case experience and experiment prove most conclusively that there is no apparent connection between viscosity and lubricating value. On the other hand, not a single one of the many able investigators who established this result had been able to establish any connection between the "oiliness" of a fluid and any of its other physical or chemical properties. This was the condition of affairs at the appointment of the Committee; but now, and at any rate partly as the result of its investigations, of which an account is given in a report* just published, we have at least a working theory as to the difference between good lubricants and bad ones, and this theory will, no doubt, be exhaustively examined by further experiment.

The Committee, which was most ably presided over by Mr. Sydney Donkin, M.Inst.C.E., included in its personnel Mr. L. Archbutt and Mr. R. M. Deeley, the authors of the standard treatise on lubrication, Mr. T. C. Thomson, the oil specialist, and Professor Vernon Boys, whose reputation as an exact and exceptionally ingenious experimentalist is international. The late Lord Rayleigh also assisted in a consultative capacity. At the outset some engineers were sanguine enough to believe that by repeating experiments similar to those already made *ad nauseum* by the railway companies and by lubricant compounders, it would be possible in the course of a few months to solve the whole problem, and professed disappointment that the Committee did not, after this lapse of time, draw up general specifications which would ensure the supply of satisfactory lubricants. In view of the vast number of what, for want of a better term, may be called "random" experiments already made, the Committee wisely decided on another procedure, which afforded better prospects of ultimate success. Sir J. J. Thomson has remarked that in "random" experiments—that is to say, in experiments made on the Baconian plan of simply accumulating facts—progress is proportionate to the square root of the number of experiments made, whilst when the investigation is guided by some theory or hypothesis which it is proposed to submit to test, the advance made is directly proportional to the number of experiments, and is thus much more rapid.

Governed by such considerations the Committee determined, in place of repeating old experiments, to ascertain what had been done before, and to compile a complete bibliography of papers on lubrication. This work has now been completed and will shortly be issued. At the same time data were collected as to all physical properties of lubricants which might conceivably be connected with their "oiliness." Amongst such properties were the surface tension, the di-electric constant, the specific heat and, of course the viscosity. It was hoped that in this way some connection might be found between lubricating value and some one or other physical or chemical quality. At the same time experiments were made with the Lanchester worm testing gear, running with different lubricants. This investigation had some analogy with many previous experiments on lubrication; but introduced one new factor, in that the pressures between the opposing surfaces were extremely high. In fact, the intensity of the pressure in such gears is so high that the gun-metal surface at times shows signs of flowing, and the pressure must in these conditions attain to the order of 30 tons per square inch. One new point was brought out in this investigation, viz., that with the mineral oils there was a critical temperature at which friction increased rapidly and irregularly. Unfortunately it was not possible to measure the temperature of the film of oil between the teeth, but merely that of the bulk, so that no simple connection between the physical properties of the oil and its "critical" temperature as observed could reasonably be expected. The results of the tests, however, confirmed the committee in a resolution previously taken to measure the viscosity of oils at high pressures. The experiments were made at the National Physical Laboratory with an extremely ingenious piece of apparatus designed by Dr. Stanton, and gave results which, unfortunately for the object, immediately in view, turned out to be more interesting than instructive. Enormous

* Report of the Lubricants and Lubrication Inquiry Committee. H.M. Stationery Office. Price 2s. 6d.

changes in viscosity with pressure were recorded. Thus under a pressure of 7·39 tons per square inch the viscosity of castor oil is 5·04 times as great as at atmospheric pressure. With mineral oils the increase was even more marked. Thus Mobiloil B.B. which has a viscosity of 1·58 C.G.S. units at atmospheric pressure, gave a viscosity of 40·07 C.G.S units at a pressure of 6·47 tons per square inch. The increase was therefore 25-fold. These results will probably prove of value in researches into the physical properties of matter and the mechanism associated with viscosity in liquids, but they appeared to have no direct bearing on the nature of "oiliness," since with the animal oils which are notoriously the better lubricants, the rise of viscosity with pressure is much less than it is with mineral oils.

Some experiments made by Mr. R. M. Deeley in his private laboratory seem, however, to throw new light on the nature of oiliness. He found that good lubricants adhered much more firmly to metal surfaces than did poor ones, and his results have been confirmed by other workers. As to why lubricating value should depend on this, two theories have been put forward in papers contributed some twelve months ago to the Proceedings of the Physical Society. Mr. Deeley's own view is that the bearing metal unites chemically with the oil, giving a surface which is itself a solid lubricant, so that in his opinion greasy friction is merely a special case of solid friction. It seems difficult to reconcile this hypothesis with the late Lord Rayleigh's experiments, in which the friction was found to be less with a film of lubricant of approximately molecular thickness, than with a thicker film. The other theory put forward is based upon Reynolds' view that in all cases of imperfect lubrication the load is concentrated on isolated spots. In that case the film at the "effective" bearing areas will be very thin and the shearing force tending to tear the oil away from the metal will be very high. For fluid lubrication as expounded by Osborne Reynolds, it is necessary that the ultimate boundary layers of the film shall adhere firmly to the opposing solid surfaces, and if the bond between the two breaks lubrication will fail. On this view greasy lubrication is a special case of fluid lubrication of which we know something, and not a special case of solid lubrication as to the real nature of which nothing is known. It is even conceivable that solid lubricants do not really exist, since the "oiliness" of the typical slippery solid ice has been shown to be really due to the melting of the solid under pressure. The film of liquid thus formed is the real lubricant. Why materials like graphite and some other solids act as lubricants is, however, still a mystery, as it has not been proved that their behaviour can be similarly accounted for, and it remains accordingly unexplained so that an attempt to interpret greasy lubrication in terms of solid lubrication appears to partake somewhat of the character of describing the obscure in the terms of the still more obscure.

According to the report, Mr. Deeley's experiments have suggested the possibility of obtaining satisfactory lubrication between plane parallel surfaces without the use of tilting devices as in the Michell blocks, and further research on this matter is recommended. It may be observed that in none of Mr. Deeley's experiments were the surfaces truly plane and parallel, but were merely commercial approximations thereto, and we believe that had the surfaces been perfect lubrication would have failed. For our own part, therefore, we trust that this recommendation will not be acted on. Marine engineers have, we fancy, exhausted this subject years ago, and proved that plane parallel surfaces cannot be efficiently lubricated, and that it is essential that ordinary thrust blocks shall be loaded to but a small fraction of the pressures habitually carried on journal bearings. Of course, Mr. Ferranti has shown that surfaces which are partially parallel can be lubricated. He washed away the leading edges of his surfaces so as to provide a wedge-shaped opening for the oil, and the late Lord Rayleigh also succeeded in lubricating "stepped" parallel surfaces, but it is not, we presume, surfaces of this kind which are referred to in the report. We regret to see from the report that the committee are retaining Beauchamp Tower's unfortunate terms known as the "on" and the "off" sides of a brass. These terms are not self-explanatory and, indeed, are always printed in italics; whereas the expressions leading and trailing sides are perfectly definite and require no explanation. The terms "on" and "off" as applied to brasses "should be relegated to an innocuous desuetude."

Some interesting experiments were made by the committee on the addition of "oildag" (Acheson's colloidal graphite) to lubricating oils. The results were not wholly conclusive, but there was evidence that the addition of oildag did most materially improve the lubricating value of certain inferior oils, whilst it seemed that little or no benefit resulted in other cases.

In concluding their report the committee suggest a somewhat extensive programme for future experiment. On the physical side the most important proposal would appear to be an inquiry into the conditions in which lubrication fails. A preliminary investigation with this end in view has already been made with a journal rotating in a glass bush, but the conditions in such a bearing are far from simple, mathematically speaking, since the pressure distribution in the oil film depends on a somewhat complicated function of the difference in the radii of journal and bush, and on the relative eccentricity of the two. It is, moreover, probable that the curvature of the bush changes with the pressure, so that it is practically impossible to compute the shears to which the oil is being subjected when failure occurs. It would be well, we think, to repeat the observations with Michell blocks, in which the conditions are more tractible to mathematical treatment. Other subjects to be investigated are the adhesion of oils to metals and the absorption of oils by metals, but no explanation is given in the report as to what, if any, is the difference between adhesion and adsorption. From the chemical standpoint the most interesting of the investigations proposed is an inquiry into the claims made by Messrs. Wells and Southcombe, that the free fatty acids present in commercial oils are the constituents which enable these oils to improve the lubricating value of mineral oils.

RAILWAY RATES.

The first report of the Rates Advisory Committee of the Ministry of Transport has been issued during the week, and suggests many important changes in the railway rate policy of the country. The Committee during the past year has issued two interim reports dealing with what may be considered stop-gap revisions, in order that the companies may be put in a position to earn sufficient revenue to render further subsidy unnecessary. The present report deals with the subject on much wider lines, and contains, in fact, proposals for the simplification of the rate-fixing machinery for the country, and outlines a future policy.

The question is a very complex one, and the conflicting interests are naturally rather difficult to reconcile. It is pleasing to note, therefore, that the Committee is able to record that a conciliatory attitude has been noticeable throughout on the part of the railway companies, who have voluntarily made very substantial concessions. As, more often than not, these companies come in for criticism rather than praise, this public recognition is very welcome. The report, it may be noted, is unanimous, and is the result of a large amount of work, in which the Committee had the advantage of evidence from the railways, traders, and so on. It undoubtedly foreshadows a great change from present methods as developed under the Acts of 1891 and 1892, and the Railway and Canal Traffic Act of 1894. Under this latter, as is well known, a situation has evolved which made it almost impossible for the companies to increase their rates, and the system now suggested should certainly prove a considerable improvement on our experience hitherto.

The present report proposes two main reforms. The first is the abolition of maximum rates, and the adoption in lieu of standard rates. The second is the appointment of a tribunal to deal with all rate matters. The first of these two proposals is a complete change from our previous national policy. It appears to us to be the only step possible in view of the extreme uncertainty of present conditions. Maximum rates fixed now may prove to be too low a short while hence; a few of the more optimistic among us may think they would prove to be too high. With the value of money so depreciated, and the cost of everything fluctuating with an upward tendency, the establishment of maxima at the present time would only be possible by a good deal of guessing.

The new tribunal which it is proposed to create would supplement the Railway and Canal Commissioners, and would deal with all questions affecting the fixing of rates, with a procedure less cumbersome than that hitherto in vogue. A tribunal to consist of three members is proposed. One, the chairman, would be an experienced lawyer. The other two would be experienced in railway business and commercial affairs respectively. They would devote their whole time to this work. In addition, it is suggested panels might be formed, one of suitable railway officials nominated by the Ministry of Transport on advice from the Railway Company's Association, and the other of representatives of the trading interests on advice from the several traders' associations. In complicated cases one person from each of these panels would be added to the tribunal. Further, local conferences of railway officers and traders are proposed for the chief centres, to act as conciliation boards before which certain affairs might be heard, but these would have no power to enforce decisions.

The actual fixing of the proposed standard rates will most likely fall to the new tribunal. The Rates Advisory Committee having now made its proposals with regard to machinery, is proceeding to classification, on which the railway companies have been engaged for some time. When this aspect of the subject has been dealt with the question of the actual rates to be charged will be taken in hand. This, it is considered, will not be possible before the Advisory Committee will have ceased to exist under the Ministry of Transport Act, and the work will, therefore, probably fall to the proposed tribunal. It is proposed on account of the size of the task, that the railways should submit scales of rates to be examined by experts of the Ministry of Transport. These rates with the experts' report would be considered by the Tribunal or Committee.

The proposals, on the whole, seem to foreshadow a much more businesslike arrangement for the future, with considerable simplification of procedure so that rates may be adjusted more readily to changed conditions. The traders have agreed to the principle of a fair remuneration for the railways, and the proposed tribunal would appear to form a fair safeguard to both sides. The new principle is introduced of an independent official body whose duty it will be to assure to the railways such rates as will bring them revenue enough to secure a reasonable return on their capital. This is a distinct departure from our national railway policy to date.

We may briefly refer to several of the other proposals made in the report. For instance, charges for collection and delivery are to be separate from the rate, and only levied when such services are given instead of as now charged, the trader having to apply subsequently for a rebate. The standard rate will be composed of a conveyance rate and of station and terminal charges, while the rate to a private siding will be a conveyance rate plus a charge for services at the siding. In the case of transit over more than one company's lines, the mileage will be considered as continuous, instead of as now each company charging its graded mileage rates over its own section of the journey. This is a reasonable modification, which the traders will probably welcome. Exceptional rates are to be abolished as far as possible. All exceptional rates which effect a 10 per cent. reduction only, it is proposed should be given up, and any which show a reduction of more than 40 per cent. on the ordinary rate will have to be justified before the tribunal. This is introduced, because if the tribunal is to be responsible for the rates bringing in a certain revenue it cannot allow the companies indiscriminate power to make exceptional rates which would involve those controlled by the tribunal being proportion-

ately higher. The conditions under which special merchandise is to be carried are to be determined by the tribunal or rates committee, instead of by the railways. An umpire in such a matter will probably be able to do a great deal of useful work, both in protecting the trader, and in assisting the railways when unreasonable demands are made upon them. The new classification it is suggested should take into account the quantity consigned.

The Committee recognises the advantage of coastwise competition but feels that this question is so large that it has not been able to deal with it conclusively. It will be dealt with in a subsequent report. In the meantime it is interesting to note that the coast-wise trade for which "entrances" averaged nearly 22,000,000 tons between 1910 and 1914, had dropped to just over 10,000,000 tons in 1919. Exceptional rates came into force years ago to meet this competition, but in spite of them the coastwise traffic flourished before the war. Since that period, however, this trade has not recovered, despite direct assistance being given, and the shipping people are naturally anxious that low rates on the railways shall be abolished. The problem is not an easy one to solve. The question of competition will come in also in the future in regard to motor transport. With the tribunal fixing rates which must be charged, the railways, it seems to us, will not be able to meet motor competition very easily, and it is quite possible that a certain amount of short distance traffic will be definitely lost to them, if they are not free to offer special rates. It will remain to be seen as road transport develops, whether rather greater freedom in charging will not become necessary in the end, always retaining, of course, easy appeal. The committee adopts a rather curious attitude on this question of competition. For instance, it considers that it has been legitimate for the railways to offer exceptional rates to secure trade which would otherwise have gone coastwise, providing the competition was not intended to destroy the competitor. But if you take his trade surely the competitor would cease to compete in time. Again, it appears that this sea competition is to be fostered, while the subsidised motor traffic is to be allowed to offer any rates they please to attract traffic away from the railways. It would seem fairer, if this competition is to be actively continued, to give the railways a much freer hand in meeting it.

THE ARTIFICIAL LIGHTING OF INTERIORS.

THAT the value of efficient indoor lighting is coming to be more generally appreciated must be obvious to the most unobservant, but, at the same time, the number of examples of crude or bad lighting which survive is surprising. This latter state of affairs may partly be explained by the many cases in which financial conditions will not allow the old-fashioned lighting of, say, a shop, or a factory, to be reformed, but to a large extent it must be attributed to the curious remoteness from any intellectual movement in which a large part of our population still live. Particularly in connection with factory lighting it might be imagined, after all which has been said about the effect of improved lighting in the reduction of accidents and increase of output, that no factory owner would be left who had not considered the matter. Actually, however, there would probably be no difficulty in finding hundreds of manufacturers apparently unaware of the fact that the matter had ever been discussed.

There are, of course, a very large number of factory owners who, although they must have had the matter brought to their attention—by makers of lamps and fittings if by no one else—yet have never effectively considered the question, having dismissed it without consideration on the score that the reformed lighting proposed was too expensive. It is clear that a mere general impression that a thing is expensive is quite a different matter from an investigation directed to ascertain to what extent the extra expenditure may justify itself, or may show a profit. It is safe to say that in most cases a profit would be shown, and, although detail investigation is necessary in any particular case, something may be proved by illustrative examples, and we would instance an interesting detail case which was mentioned by Mr. W. E. Bush of the British Thomson-Houston Company in a paper read before the National Association of Supervising Electricians on the 14th inst.

The case worked out by Mr. Bush related to factory lighting and was based on the use of 100-watt gas-filled lamps with reflectors. One lamp per operator per 100 sq. ft. was assumed and that the lamps were to be in use two hours per day, 300 days in the year. Taking the cost of lamps and reflectors at list prices, on which there would actually be a discount, and estimating the cost of wiring at 4*l.* a point, it was shown, after allowing for renewals, cleaning, power at 3d. a unit, and interest on expenditure at 6 per cent., that the annual cost per lamp would be 43*s.* If, then, it was assumed that the wages of the operative who worked by the light of one lamp amounted to £300 a year, the ratio of the cost of lighting per man to his wages was 0.716 per cent., or in other words, if the workman saved 4 minutes a day as a result of the efficient lighting the entire cost of operating the lighting system would be paid for. The scheme described would give a light intensity of about 5 foot-candles which is quite an adequate amount, and, although it may be objected, that the operative's wages have been set at a high figure for an average case, it is obvious that the total cost of lighting forms a very small proportion of production costs. It is pointed out that if the man saves four minutes a day, the cost of the lighting is paid for, but as a matter of experience and test, an increase of output up to as much as 20 per cent. has been obtained by substituting good lighting for bad in workshops.

We have at the present time in this country no statutory regulations dealing with lighting in works and factories other than for underground bakehouses, in which the light must be "adequate," and for certain special cases in the manufacture of pottery, vitreous enamelling, the generation of electric energy, and the use of locomotives, in all of which cases the light again must be "adequate." It is very possible, however, that in the not very distant future legislation may be introduced dealing with the matter. The subject would appear to be one likely to appeal to some of our present Ministries. In 1913 a Departmental Committee was appointed to report on the matter, and in 1915 they issued a preliminary report, but we are afraid we have no knowledge of what has happened to this committee since that time. We have lost it in the course of the war. As we have said, however, it would be a matter of no surprise if some new Government move were made in connection with this matter. It is closely bound up with questions of accidents and health and lends itself readily to specific regulations.

With all due respect to the illuminating engineers we cannot look upon the adequate lighting of a factory as other than a very simple matter. We admit that if one went to the average electric wiring contractor and told him to prepare a scheme to give a minimum horizontal illumination of 0.5 ft. candles at floor level in a workshop, and a minimum illumination at 3 ft. from the ground of 5 foot-candles for work benches and machines, he might be considerably at a loss. The reason for this, however, would not be that the problem was a difficult one, but that the wiring contractor did not know much about his own job. There are very many electrical wiring people, works engineers and others concerned who have never given this subject any attention, but in view of its growing importance and its close connection with the vital question of production costs, it is very desirable that they should begin to take an interest in it.

To all such people to whom artificial lighting is a matter of everyday importance, but to whom such terms as "lumens" and "intrinsic brilliancy" are so much Chinese, we would commend the paper by Mr. Bush to which we have already referred. Mr. Bush's firm, the British Thomson-Houston Company, has done much to improve indoor lighting and has introduced various excellent reflectors and other details in addition to the well-known Mazda electric lamps, and the practical results of its work are presented in an easily usable form by Mr. Bush. The spacing and height of the individual lamps is dealt with and an actual case for a weaving shed 60 ft. by 48 ft. by 11 ft. high is worked out to give an intensity of 4 foot-candles on the looms. Mr. Bush also gives a chart from which the illumination given by various arrangements of lamps may be read off directly.

There is but little doubt that the illumination of workshops and factories would receive more attention, and bad examples would be rectified if works engineers or others concerned would make use of a foot-candle meter as an every-day workshop instrument. The unaided eye is a very poor judge of illumination intensities, but if a practice is made of actually reading and recording the candle-power in every important part of a factory remarkable variations will probably be discovered and a general improvement of the bad patches is likely to be undertaken. If all machine and bench illumination is brought up to 4 foot-candles or 5 foot-candles a very remarkable improvement will be introduced into many shops. The foot-candle meter is a simple portable instrument with which the illumination in any place may be compared against the illumination produced by a standard battery-fed electric lamp inside the instrument. In the instrument described by Mr. Bush a series of translucent dots, which serve the same purpose as the grease spots in a Bunsen photometer, line the scale from end to end. When the instrument is in use these spots appear brighter at one end of the scale than the other and at the point at which the spots are neither lighter nor darker than the scale the illumination from within and without are equal. This enables the foot-candle intensity at any point within the range of the instrument to be read off directly. There are other instruments of the same class, in one the interior lighting of a screen being varied by swinging a reflector which alters the angle of incidence of the rays on the translucent screen by which the inside and outside lights are compared.

TWO REVOLUTIONS IN NAVAL WARFARE.

IN the history of naval warfare two battles stand out as landmarks, as they completely revolutionised the ideas of the leading naval authorities of their time. The one was the fight against the Spanish Armada, fought in the last week of July, 1588, and the other the fight of the Merrimac against the Federal squadron in Hampton Roads in March, 1862. How great the effects of these two battles were can be seen by a study of the naval warfare before and after them.

From the earliest times to the days of the Spanish Armada, sea fights had been decided in much the same way, namely by boarding, the essential use of the ship being, in fact, to carry infantry. Further up to this time the principal method of propelling a war vessel was by means of oars. Rams were used to a certain extent, but in the main, the fleet actions appear to have been hand to hand fights. These tactics were worked out by the Ancient Greeks and remained in use till the latter part of the sixteenth century.

Fights on these lines therefore depended on the physical strength of the combatants, their numbers and their discipline. The last great fight in which both sides used this style of warfare, was Lepanto, and a very interesting comparison can be made between this battle and that against the Spanish Armada. These two fights took place within 17 years of each other, and in both cases the question at issue was what race and religion should have command of the sea. At Lepanto the issue was between the Christian and the Turk, and representatives of every Christian country were gathered against the latter. The numbers engaged were probably greater than those in the fight between us and the Armada, and the result was a decisive defeat, at sea, for the Turk, from which he never recovered.

The battle was principally remarkable as being the last in which the old-fashioned way of fighting was employed, for the galleys which formed the majority of the fighting ships were very little different in principle from those used by the Ancient Greeks and Romans. Guns were used to a certain extent, but did not have a decisive effect. The Turk having

been disposed of, the issue then lay between the Protestant Saxon and the Catholic Spaniard, and here the Spaniard was decisively beaten. In this fight, however, a new method of fighting proved to be successful and the result revolutionised the navies of the world.

Although the sailing vessel had to a large extent taken the place of the galley propelled by oars in the Spanish fleet, the essential method of fighting remained hand to hand. The Spanish Armada carried over 21,000 soldiers and 8,000 sailors, and the Spanish soldiery were the best disciplined and most efficient in Europe at that time.

Ships of the Royal Navy, 1588.

Name.	Tonnage.	No. of Crew.	Guns. 60-pr.	32-pr.	18-pr.	9-pr.	6-pr.	5½-pr.	Smaller Pieces.	Total.
Triumph	1,100	500	4	3	17	8	6	—	4	42
White Bear	1,000	490	3	11	7	10	—	—	9	40
Elizabeth Jonas	900	490	3	6	8	9	9	1	20	56
Ark	800	430	4	4	12	12	6	—	17	55
Victory	800	430	—	—	12	18	9	—	3	42
Mary Rose	600	250	—	4	11	10	4	—	7	36
Hope	600	270	2	4	9	11	4	—	18	48
Elizabeth Bonaventure	600	250	2	2	11	14	4	2	12	47
Rainbow	500	250	—	8	10	14	2	—	20	54
Golden Lion	500	250	—	4	8	14	9	—	3	38
Vanguard	500	250	—	8	10	14	2	—	20	54
Revenge	500	250	2	6	12	2	6	4	11	43
Nonpareil	500	250	2	3	7	8	12	—	6	36
Antelope	400	170	—	—	4	13	8	—	5	30
Dreadnought	400	190	2	—	4	11	10	—	5	32
Swiftsure	400	180	2	—	5	12	8	—	15	42
Bonababla (galley)		250	—	—	—	—	—	—	—	—
Swallow	360	160	—	—	—	—	—	2	6	8
Foresight	300	150	—	—	—	14	8	3	12	37
Aid	250	120	—	—	—	8	2	4	4	18
Bull	200	100	—	—	—	—	—	—	—	—
Tiger	200	100	—	—	4	8	8	—	10	30
Tremontana	150	70	—	—	—	—	12	7	2	21
Scout	120	70	—	—	—	—	4	—	6	10
Achates	100	60	—	—	—	6	—	2	5	13
George	100	24	—	—	—	—	—	—	—	—
Charles	70	45	—	—	—	—	8	—	8	16
Moon	60	40	—	—	—	—	4	4	1	9
Advice	50	40	—	—	—	—	4	2	3	9
Merlin	50	35	—	—	—	—	—	—	7	7
Shy	50	40	—	—	—	—	4	2	3	9
Sun	40	30	—	—	—	1	—	—	4	5
Cygnet	30	20	—	—	—	—	—	1	2	3
Brygardine	90	35	—	—	—	—	—	—	—	—
Totals	12,326	6,289	26	63	151	207	153	34	248	890

Table of Ordnance, 1588.

Name of Piece.	Bore.	Length.	Weight of Gun.	Weight of Shot.	Powder Charge.	Point Blank Range.	Random Range.
	inches.	ft. in.	lbs.	lbs.	lbs.	yards.	yards.
Cannon	8	—]	6,000	60	27	340	2,000
Demi-cannon	6½	11 0	4,000	32	18	340	1,700
Culverin	5·2	10 11	4,840	18	12	400	2,500
Demi-culverin	4	—	3,400	8	6	400	2,500
Saker	3⅞	6 11	1,400	6	4	340	1,700
Minion	3½	6 6	1,050	5½	3	340	1,600

To meet this we had the ships of the Royal Navy carrying just under 6,300 men of all sorts. In addition there were numerous privateers, and it is possible that the total number of men we had in the fight was about half that of the enemy. A great many of our men were, however, dispersed in small ships and a very large proportion must have been quite untrained in "infantry" tactics. It is, therefore, evident that if the Spaniard could have engaged our ships hand to hand, he would have had a complete victory. How then did we meet the danger? Simply by pitting the use of brains against brute force, and using our ships as real fighting machines. Oars were quite abandoned as a propulsive force and sails used exclusively, and the ships were made as fast and handy as was then possible. This allowed us to choose our fighting range, while for offensive purposes the ships were armed with a great number of very heavy guns. Our method of fighting was, therefore, to choose our range and make use of superior gun power, never letting the enemy close. This method of warfare had, of course, been developed in the various actions between single ships and small squadrons, which had taken place in the years before the Armada, but had never been seen in a big naval battle. It is very seldom realised how heavily the English ships in the Armada fight were armed. The above tables of the armaments of the ships and of the ordnance of the day taken from Laird Clowes' History of the Navy, will show that practically every gun it was possible to get on board was crammed into the ships, and that these guns were very powerful. It must be remembered that by this time the muzzle-loading gun had superseded the primitive breech-loader, and that the majority of the guns in the Royal Navy were of brass.

Thus, we may take as an example, the Revenge, famous afterwards for her fight off the Azores. This was a medium-sized ship of 500 tons. Although so small, she carried 20 guns of 18-pr. and upwards, there being two 60-pr., six 32-pr. and twelve 18-pr. Besides these, she carried two 9-pr. and six 6-pr., as well as smaller guns. This is an enormous armament to put in a ship this size, as will be seen if it is compared with the armament of a 500-ton ship of the days of Nelson.

Besides this, the guns were very powerful for their calibre. Thus, as shown by the above tabular statement, the "culverin," or 18-pr., was practically 11 ft. long, or 25 calibres, weighed two tons, and fired a charge of 12 lbs. of powder or two-thirds the weight of the shot. Some of the smaller guns appear to have had powder charges nearly the weight of the shot. When we consider that the largest charges of black powder ever used in the modern high-velocity guns was about two-thirds the weight of the shot, it is evident that even making every allowance for poor workmanship, these were very powerful weapons. In fact, the Tudor gunmaker appears to have started where we have now finished, namely, with a long gun and a very large charge of slow-burning powder. Such guns would be very slow to work, which is doubtless the reason they were given up in later years and the gun made shorter and handier, but they would also hit very hard, a matter of great importance in those days, as ships were probably very massively built. It is also hardly a matter of surprise that after two days pretty continuous fighting with these large powder charges, the ammunition of the ships was exhausted.

The result of the fight is, of course, well known, but it is not always realised how little loss we suffered in comparison with the enemy. Unable to close and use their numbers, the Spaniards were mercilessly hammered by our ships. In the words of their commander-in-chief: "The enemy pursue me—they fire upon me from morning until night—but they will not close and grapple—they are swift and we are slow." How many of their men we killed in actual fight we do not know, but it was enough to cow them completely and drive them up into the North Sea and round Scotland, where large numbers of them perished. Our loss in the actual fighting appears to have been very small indeed, judging from the fact that it is stated that no "gentleman of rank" was killed. Considering that there were large numbers of such "gentlemen," and that they exposed themselves a great deal, this implies very small total loss. In fact, the above words of the Spanish Commander are a very eloquent statement of the helplessness of a force trusting solely to numbers and discipline as compared with one which in addition uses brains and mechanical appliances.

In considering the result, we must not forget to admire the pluck of those governing a small country in staking the whole national existence on what was then a quite novel method of fighting a naval battle, especially as this method was not one which was approved by the leading naval powers of the time.

The defeat of the Spanish Armada completely revolutionised the naval warfare of the time and from then onwards the command of the sea was determined by the use of the ship as a fighting machine. It is true that ships were occasionally taken by boarding, but this was in practice a comparatively rare event, especially in fleet actions.

Some people appear to have an idea that boarding was the favourite method of fighting in the British Navy of the period between the days of the Tudors and the end of the Napoleonic Wars, but a study of the details of both the fleet actions and also those between single ships, will show that the number of ships taken by boarding was small, and also that the large majority of those which were boarded had been subdued by gunfire first. Even the famous Chesapeake, taken by the Shannon by boarding in a quarter of an hour after the fight began, was only boarded after the gunfire had begun to force the guns' crews to desert the guns, and she was so damaged by gunfire that she was never again put into service. Obviously, when the gunfire of a ship had been subdued, she could always be destroyed by gunfire without boarding, and the preference of the naval men for finishing a fight by boarding was no doubt due to the fact that they did not desire to sink ships if they could avoid it, as they wished to bring them home as prizes, probably, or at all events partly, for the sake of the prize money.

The ship and gun having been practically standardised, little further progress was made for 250 years. In detail, the ships were improved, and so were the guns, but the wooden sailing ship with smooth bore guns held the sea till after the Crimean War. Steam was tentatively introduced, but only as an auxiliary in the larger ships. The tendency again, therefore, became to rely on numbers, and ships were built carrying 130 guns. To anyone who looks back at the mechanical progress of civil life, it is easy to see that the navies of the leading powers of the world had quite lagged behind the times in the use of science, and had come again to rely again on numbers. As in 1588, there was a rude awakening.

On March 8, 1862, the Merrimac steamed out of harbour to attack the Federal squadron in Hampton Roads. She was an old 40-gun frigate which had been set on fire and sunk by the Federals when they abandoned the Gosport navy yard, but had been raised by the Confederates and converted into a primitive ironclad. A sloping casement had been built over the top of the vessel plated with bar iron. The guns were reduced to ten: two 7-in. and two 6-in. rifled, and six 9-in. smoothbore. The whole ship was very defective, as can be judged from the fact that she could only steam 5 knots and took half-an-hour to turn, but the resources of the South were very limited. The result of her conflict with the wooden ships was, however, decisive. The Cumberland, 30 guns, was sunk and the Congress, 50 guns, forced to surrender, the casualties on the Merrimac being very small.

Luckily for the Federals, they had been building the famous Monitor, an ironclad turret ship carrying

two 11-in. smooth-bore guns in a revolving turret. This arrived in Hampton Roads on the night of March 8, and next day ensued the battle between her and the Merrimac. The result of this fight was inconclusive, neither side being able materially to damage the other, and eventually both drew off with negligible casualties.

The result of these fights was again completely to revolutionise naval warfare. The stately three-decker with her innumerable guns and men became a complete back number, and for all practicable purposes the navies of the world were scrap and had to be re-built. Primitive as the Merrimac and Monitor were, they were the forerunners of quite new developments. Even before the end of the Civil War the Federals had double-turreted ships, without masts, plated with some 10-in. of armour, and carrying four 15-in. smoothbore guns, which in their day were very formidable weapons. It took many years for some of the features of these ships to come into general use in European navies, the opposition to the use of mechanical science being very strong. Thus, masts and sails were retained for a long time, and guns placed on the broadside, but the change in principle was firmly established, and every navy in the world now recognises that numbers and discipline by themselves are no match for brains and mechanical science.

The history of the two fights dealt with above is very interesting at the present time, in view of the experiences of the late war on land. Here the armies trusted mainly to numbers and discipline, and mechanical, science was relatively little used on either side. There is no reason why mechanical science should not be, employed to as great an extent on the land as it is on the sea, and it is quite certain that the first country which has the imagination and pluck thoroughly to exploit it will effect as great a revolution in land fighting as either of the above battles did on the sea, and the country so acting will then dominate the world.

NOTES.

THE WAGES (TEMPORARY REGULATION) ACT, 1918.

Mr. Justice Roche delivered a judgment last week in a number of cases under the Wages (Temporary Regulation) Act which, if not over-ruled, will have the effect of freeing employers from future trouble arising from the provisions of the Act. As is well known, the Act regulated wages, by making the payment of "prescribed rates" obligatory, for the period of six months from November 21, 1918. This period was extended by a second Act until November 21, 1919, and, later, by the Industrial Courts Act, 1920, the third Act of the series, until September 30, 1920. The question at issue was whether legal proceedings which had been commenced before munitions tribunals prior to September 30, 1920, in respect of alleged failure to pay prescribed rates could be carried out to a final decision of Mr. Justice Roche, on appeal, after that date. The difficulty arose in this way:—Although in the Act of 1918 the period during which wages were to be regulated by it was fixed at six months, no time limit was set to the provisions of the Act relating to its enforcement by means of legal proceedings before the munitions tribunals, &c. Accordingly, if the original Act had stood alone legal proceedings under it could have been commenced and carried to a conclusion after the expiry of the six months. The second Act, however—the Wages (Temporary Regulation) Extension Act, 1919—enacted that the original Act—*i.e.*, the whole of the Act—was to continue in operation until November 21, 1919. This, on the face of it, seems to have fixed a time limit for the whole of the Act; but the matter did not rest there, for the Industrial Courts Act, 1919, which modified the provisions of the original Act slightly, enacted that they were to continue in operation, subject to the modifications, until September 30, 1920. The real question was, therefore, whether the two later Acts had amended the original Act in such a way as to make all its provisions merely of a temporary character. Mr. Justice Roche decided that they had, and that after September 30, 1920, the tribunals had no right to proceed further with the cases under the Act which were then pending before them and that he had no longer any jurisdiction or right to deal with them on appeal. From this decision there is no direct appeal, although Mr. Justice Roche indicated that it might be more satisfactory if his judgment were brought under review indirectly by some such procedure as an application to the High Court for an order directing him to hear the appeals. Meantime, and so long as the judgment is not over-ruled, employers will be immune from further trouble before the munitions tribunals in regard to the temporary regulation of wages.

AFTER-CORROSION OF THE BORES OF FIREARMS.

During the war the United States Bureau of Mines was engaged in an investigation of the causes of the corrosion sometimes appearing on the oiled bore-surfaces of firearms subsequent to the use of smokeless powders. The Ordnance Department stated that more rifles were ruined by improper preparation for storage than by any other cause. The various authorities and practical riflemen differ as to the conditions favouring the corrosion and the means of its prevention. Black powder is believed not to cause corrosion. The modern high explosives are said to leave acid residues which corrode the barrel, especially in moist atmospheres, unless removed by swabbing the bore with alkaline compounds (sodium carbonate) or special organic compounds, recommended in considerable variety, followed by oiling.. The hot acid gases are also believed to be forced into the steel and to be occluded by the steel, from which they leak and sweat out slowly in the course of weeks and months, in spite of repeated swabbing and oiling. The primers have sometimes been held to be particularly responsible for this corrosion. The investigation conducted in the Explosives Laboratory of the Bureau of Mines, of which Wilbert J. Huff gives a detailed account in the *Journal of Industrial and Engineering Chemistry* of September last, pages 862 to 870, shows that both the cause and the cure of the corrosion are simpler than was suspected. The experiments were made with rifles of models of 1903 and 1917, charged with standard service cartridges primed with fulminate, sulphur cyanide, and sulphur compositions, &c. Qualitatively the explosives all behaved very much alike. Hundreds of rounds were fired; the rifles were then swabbed, cleaned with various commercial preparations and chemicals, and oiled and kept for long periods in atmospheres of known humidity, ranging from zero to saturation. It was found that the modern high-pressure smokeless cartridges do not in general leave any nitrocellulose residue, nor other acid residue. After-corrosion is due to the explosive deposition of water-soluble salts, in whose aqueous solution the steel corrodes, and to the subsequent exposure to high humidity in the presence of oxygen. The chief culprit is the potassium chloride resulting from the decomposition of the potassium chlorate in the primer. The sweating-out of acid was not observed. The various remedies owe their efficiency to the cleaning out of the soluble salts. That the use of mechanical tools and abrasives for cleaning does not remove the corrosive salt and hence does not prevent the apparent gas occlusion and sweating-out, is explained by the fact that the salt remains in the "tool wounds," scratches, fissures and pits, of the barrel unless washed out. This washing may be performed by placing the barrel mouth in hot water, using the swab as a piston pump for several minutes. The various chemicals (soda, &c.) act merely as solvents and cleaning agents. The dried barrel should subsequently be corked tightly at both ends. No corrosion need, in general, be feared if potassium chlorate be kept out of the primer. There is, however, a possibility of acid after-corrosion when nitrocellulose is used at low gas pressure, because combustion then remains incomplete. Such low-pressure explosion takes place, for instance, when blank cartridges are fired; this point, however, is further being studied.

TRADERS' BLACK LISTS.

The question of the right of traders to publish "black lists" of persons to whom they refuse to allow their goods to be supplied was the subject of an important judgment given last week by the Court of Appeal in the case of Ware and De Freville Limited, *v.* The Motor Trade Association and others. The facts may be outlined as follows:—In 1919, when the demand for motor cars exceeded the supply, the plaintiffs were asked to sell a Vauxhall car on behalf of a person who had bought it but had never used it. They offered it for sale at a price high enough to give a profit to themselves and a profit to an intermediary who had introduced the business to them. This price was considerably higher than the price in the Motor Trades Association's "protected list," and the Association threatened to place the plaintiffs' name on their published lists of persons who had sold or offered for sale any articles in the Association's protected lists at a price above or below the price in the protected lists. As this would have resulted in the plaintiffs being unable to acquire, directly or indirectly, any of the articles on the protected lists they applied for an injunction against the Association and certain of its officials, in order to prevent the publication of their name on the lists. They alleged that the defendants had unlawfully conspired to injure them and had unlawfully threatened to place their name on the "stop" lists. Mr. Justice Rowlatt granted the injunction against certain of the defendants, on the ground that they were attempting to prevent the plaintiffs from exercising their legitimate rights; but the Court of Appeal recalled the injunction on the ground that the defendants, in publishing the "stop" lists, were merely exercising *their* legitimate rights as traders and were not attempting to attain their objects by any unlawful means. They were not seeking to induce any one to break any contract with the plaintiffs, as was done in the undertaker's case, discussed in our columns last week, and their object was the legitimate one of preventing, in the interests of the members of the Association, speculation in the cars and other articles manufactured by the members. In other words, they were acting *in bona fide* in the protection of their trade interests. The judgment does not differ in principle from certain earlier judgments in regard to "black lists," but it is probably the most authoritative pronouncement on the subject. The real difficulty in all cases of alleged conspiracy arises from the conflict of judicial opinion to be found in the judgments delivered in the House of Lords in the famous cases of Allen *v.* Flood and Quinn *v.* Leathem, for it would pass the wit of man to reconcile them all.

LITERATURE.

The Theory and Practice of Aeroplane Design. By S. T. G. ANDREWS, B.Sc., and S. F. BENSON, B.Sc. London: Chapman and Hall, Limited. [Price 15*s.* 6*d.* net.]

THIS book is one of the "Directly-Useful Technical Series" of Messrs. Chapman and Hall, who are endeavouring, in this series, to supply to technical people, either students or those in practice, a class of book occupying a midway position between the purely theoretical book, on the one hand, and the practical book that tends to omit the scientific basis of the subject on the other. The information to be afforded, and the problems and exercises set are intended to be of a directly useful character, but at the same time sufficient scientific explanation is included to satisfy the inquiring mind.

The authors of the book under review are to be congratulated upon the way in which they have fulfilled these conditions. Their book covers most of the ground in aeroplane design and is written in a very clear manner, which should appeal particularly to the elementary student. Although there is very little in the nature of original work—a feature usually looked for in a book written during the infancy of a subject—the work is excellent as a clear exposition of accepted thought in aeronautics and as a collection of useful data. The principles, on the whole, are sound, and every effort is made to give due prominence to the more theoretical aspects of the subject. The works of Eiffel and the Advisory Committee for Aeronautics, and the publications in *Flight* have been utilised to supply the bulk of the material, and we sincerely hope that, in the next edition of the work, the secretary of the

National Physical Laboratory will add his quota, viz., the photographs for which the authors, as they inform us in their preface, have been waiting since August, 1919. The subject is treated in 14 chapters, producing 450 pages of text, of which almost 150 are devoted to aerodynamics and 120 to structural design. The mathematical theory of stability, which will probably be a stumbling block to most students, is discussed in about 40 pages.

The sequence of the chapters appears to us to be capable of improvement. General, or experimental, aerodynamics is interpolated between chapters upon structural work and seems to be scattered throughout the book for no apparent reason. For example, we find Chapters V, VII and VIII dealing with such similar subjects as the structural design of the wings, the fuselage and the chassis, respectively, while Chapter VI deals with "Resistance and Streamlining"; this chapter could very well have been given before Chapter III on aerofoils. The "Design of Control Surfaces"—purely an aerodynamic chapter—is well away from its fellows, and the fact that stability is mentioned in it once or twice does not warrant its being placed after the mathematical chapter on that subject. Many students will ignore the stability but read the chapter on control surfaces with profit.

The first two chapters are of an introductory nature, but one cannot help feeling that, in a book such as this, space should not be wasted upon Hooke's law, elementary stress diagrams and Bow's notation. It upsets the balance and lowers the tone of the book, serving no useful purpose except to those who should not be encouraged to take up science or engineering as a profession. The third chapter, on the aerofoil, is well set out and very useful, but, since it attempts to supply data for design, it is unfortunate that the extensive work carried out upon this subject at Teddington and at Farnborough during the war has been ignored. Chapter IV could very well be deleted, since it deals only with the elementary beam theory and should be known by every engineering student. It also seems rather unnecessary to give an example on the detailed calculation of the moment of inertia of a strut section resulting in a table occupying two pages. The final result is given correct to nine significant figures (28509652·1), the section being divided into 70 parts for the calculation! We hope the forces on the strut and the properties of the material are known to the same accuracy. The chapters on the design of wings, fuselage and chassis, should be found easy reading to most students. These chapters contain some very useful data, but at times the work seems to be unnecessarily elementary.

The mathematical theory of stability has been treated along the lines of Professor Bairstow, and may be found beyond the powers of most readers. The mathematical logic is not strictly sound, and would not be accepted by mathematicians. Formula 92, on page 313, does not follow from formula 90, page 312 (the record equation). The error is due to the fact that the ϕ and ψ in $p = \delta\phi/\delta t$ and $r = \delta\psi/\delta t$ are not the same as the ϕ and ψ used when gravity is resolved along the three axes of reference. The angular velocities p and r can only be written as $\delta\phi/\delta t$ and $\delta\psi/\delta t$ when the fixed axes of reference for rectilinear flight are chosen so that the angles between them, and the moving axes at any time, are first order quantities. Messrs. Andrews and Benson have evidently made use of an artifice used in a certain book on aeronautics without completely understanding it. It is fortunate for them that they have the work of others to bring them right in the end.

In three chapters, it is to be noted, the authors discuss the subject of skin friction. This should be contrasted with the scant space devoted to such an important matter as dynamical similarity. We admit that skin friction has all the outward appearances of being of great practical importance, but this importance is more apparent than real. Calculations upon the resistance of an airship from Zahm's figures give a result twice, or thrice, as great as that of the actual resistance, whereas with a lesser faired form the actual resistance is usually far greater than the skin friction; the value of skin friction data speaks for itself.

Apart from the above criticisms, Messrs. Andrews and Benson's book has much to commend it especially to the elementary student. Its value is in its collection of data and the fair presentation, without comment, of the works of others in aeronautics. We have, therefore, no hesitation in recommending this book to designers and elementary students in aircraft.

Oil Finding: An Introduction to the Geological Study of Petroleum. By E. H. Cunningham Craig, late of H.M. Geological Survey. Second edition. London: Edward Arnold, 1920. [Price 16s. net.]

With the continually increasing demand for petroleum the search has become more eager and intense, while frequent disappointment has taught the necessity of combining and systematising all accumulated information, with the view of improving the chances of success and preventing the losses due to "wild cat" drilling. Hope often outruns prudence, and illusory signs are followed, while the whispered caution of riper knowledge goes unheeded. Guides are needed though their advice is neglected, but in the author we have one whose experience of oil-fields is undoubtedly large and varied, and as in this book he places before the public the kind of knowledge that is essential, and the most practical way of using that knowledge, it is to be hoped his advice will not be neglected. Unfortunately, it must be admitted, that in oil exploitation, facts are more certain than deductions and inferences. The history of the industry has amply demonstrated that though it may be possible to say where oil will not be found, it is impossible to say where it will be encountered on a sufficiently large scale to make boring profitable. Chance unguided by knowledge has often been successful, while the most careful mapping and exploration has ended in failure. All the indications which experts have found trustworthy may be present, the geological structure hopeful, the signs abundant, and after much labour, the oil sands may be reached, but the quantity of oil yielded may not prove commercially remunerative.

Barbadoes and New Brunswick afford sufficient instances of illusory hopes. The presence of a small quantity of heavy petroleum or occasionally the evidence of a filtered oil may prove that the oil was once there, but has disappeared in the alternations of long geological periods when the bed of the ocean was by turns uplifted and depressed, as one age succeeded another, and the luxurious forests of the carboniferous era flourished for a while in the sun, only to sink again beneath the sea. Recalling the evidence of jointed, faulted, and folded rocks, the wonder is rather that the overlying formations should ever prove sufficiently effective to prevent the dispersion of the oil, more especially when we consider how easy it is to break through the carefully concealed pockets and liberate the long hidden contents.

A knowledge of the conditions that have promoted the formation and the circumstances that have led to the concentration and preservation of petroleum is, therefore, of vast importance to the commercial world. An immense inheritance, representing some tiny fraction of the sun's radiant energy operating in past ages, has been locked up and the key is, unfortunately, missing. Chemists explain how petroleum might be made, and geologists declare the tectonic movements of the globe that have provided the necessary reservoirs, and fitted them with impervious covers to retain the elusive mineral secure. But it must be admitted that the agreement between our scientific advisers is not complete. Counsels are divided and uncertainty prevails. There is no doubt that petroleums have been produced synthetically in the laboratory, and the chemist may claim that he has solved his share of the problem, but the geologist insists that notwithstanding any success the chemist may boast, he has employed methods which could not possibly operate in nature. On the other hand, the geologist in his turn, will sometimes propose a solution that chemists declare to be absolutely impossible. Mr. Craig complains that authors in the presence of conflicting evidence are inclined to maintain a non-committal attitude, that does more credit to their judicial faculties than to the depth of their researches. Certainly this charge of halting between two opinions cannot be brought against the author. We may not always agree with his conclusions, but they are expressed with decision and conviction.

The origin of petroleum is one of those points on which a hesitating ambiguity is apt to be shown. The possibility of an animal origin is dismissed with some contempt, as a hypothesis that has been maintained more by argument than by active research, and one that finds no support from facts gathered on the oilfield. The author who, it will be remembered, occupied the position of chief geologist and deputy director of the Petroleum Research Department, throws the weight of his authority in favour of a vegetable origin, but of strictly limited operation. He must not be understood to give his consent to a possible distillation from coal or lignite, against which the mass of evidence is conclusive, nor is any process of distillation necessarily involved. It is stoutly maintained that petroleum is formed from the remains of terrestrial vegetation "accumulated in clays, sands, or actual beds (which under other conditions would develop into carbonaceous shales, sandstones, and seams of coal or lignite) by natural processes, which can be not only reproduced in the laboratory, but can also be proved to have taken place in the past and are taking place at the present day." If the deposit has reached the lignitic or coal stage, no assumptions regarding possible variations of temperature or pressure are found sufficient to explain the possibility of a complete transformation into petroleum. Instances are quoted, in which tree trunks have been able to reach the lignitic stage, while the less resisting vegetable debris has been converted into petroleum owing to the increased pressure due to the accumulated sediment. There is nothing vague or uncertain about the author's method of enunciation. He has reached a conclusion which absolutely satisfies his observations and deductions, and we hear nothing of catalytic action by anaerobic enzymes after inclusion in sediment, a theory which has had its advocates and still counts many supporters. The author relies entirely on terrestrial vegetation, using the term in a restricted sense, as the only possible origin that can satisfy the demands of the geologist, the chemist, and the physicist, but while admiring this firm and positive attitude, it is difficult to believe that in the long course of ages with shifting environment and varying conditions, other sources have not contributed to a result, differing widely in chemical combination. Here again, the author will admit of no compromise in the differing asphaltic and paraffin oils. He contends that as in the gradations of coal from the least mineralised lignite, through bituminous coal to anthracite, an essentially commom origin prevails, so all crude petroleums have been formed in the way indicated. Mr. Craig insists so energetically on the purity of origin that he will not admit seaweeds and fucoids to have contributed any small share to the common product. The objection to their inclusion seems to be based on some possible errors in identifying the traces of fucoids. The argument founded on lack of quantity is of no great weight, for it would merely imply that longer time was required for collection and deposit. Perhaps a more legitimate objection is found in the proved absence of bromides and iodides, but if the author thinks that by narrowing the choice of materials, he will gather a unanimous support to his views, we are afraid he will be disappointed. Evidence from all parts of the world is increasing, and it becomes more and more difficult to combine the whole facts into one scheme. A common agreement of opinion is hardly to be expected, and the question still remains *sub judice*.

The consensus of opinion is more marked in declaring the behaviour of petroleum under ground, its method of storage, and the circumstances that promote migration. The latter is generally admitted to be of a circumscribed character, for the conditions that have contributed to the preservation of oil in a particular locality are not likely to be repeated within a limited area. Where migration has been possible, dissipation has probably followed, and many instances are known where entrance has been effected into a depleted store, from which the crude petroleum has long since departed. A good porous reservoir is necessary to retain the oil,

and if this essential is wanting, whatever other favourable "signs" may exist, the petrol will prove of but small value. The Calgary field is a well-known illustration. There, geologists and oil experts demonstrated the presence of suitable geological structure indicated by the anticline, sufficient raw material to form the oil, and an impervious cover to prevent dissipation, but the field has failed to realise expectations solely owing to the absence of a good thick porous reservoir rock.

The work of the geologist or oil prospector is to discover such porous rocks capable of preserving the petroleum from dissipation, and other formations that will ensure sufficient concentration to warrant outlay on further examination. The methods to be pursued are set out with great lucidity and detail. The guidance is as thorough as experience gained in many parts of the world can make it. Though at any fortunate moment, the waywardness of chance may award success to schemes unsupported by scientific exploration, yet in the long run the systematic examination of the ground and the knowledge acquired from careful mapping must give an advantage to the painstaking expert. And as the great prizes in the lottery are drawn, and the suitable areas are more closely explored, true scientific investigation will be adhered to more strictly. Moreover, it is only by such means, that is, by the acquisition of exact knowledge that the capitalist and the investor can be adequately protected. The disastrous history of the Maikop flotation in 1910 carries a warning to those who neglect the teaching of science, for the delusive fallacies of hope. The lesson comes too late to prevent loss, but it may furnish a guide under similar circumstances that are pretty sure to be repeated in the future. A knowledge of the geological structure and a competent interpretation of the collected facts should have convinced the least expert that successful results over a wide area were in that case impossible. The Maikop field is a monocline with local irregularities, and a monocline, says Mr. Craig, "save under exceptional conditions, can never rival an anticline or dome as a petroliferous structure."

The indications of petroleum both on the surface and those encountered in drilling are treated at very considerable length, and the grounds for the conclusions drawn are supported by a wealth of illustration, drawn from many oil fields, but uncertainty of interpretation generally prevails. The author rather humourously tells us that while many a chairman of oil companies reports that the manager cables that "the oil indications are favourable," and the shareholders go away thankful and satisfied, it is probable that neither the field manager nor any expert "has any certain knowledge of what would be favourable indications in that locality and at the depth stated." These uncertainties may be both instructive and amusing but we omit any reference to them, as also to natural gas or gaseous petroleum, a subject of vast importance, in order to ask how far the most trustworthy indications betoken the existence of oil producing strata in this country.

The importance of the issue is such as to render strict enquiry essential, and all possible information should be placed at the command of the public. Owing to the urgency of the need, there is a natural tendency to overlook the unfavourable factors, and to exaggerate those that prophecy sooth. The most sanguine dreams and hopes of interested parties will not give us petroleum if it is not there, and it must be remembered that the most improbable wild cat schemes have always been able to quote in their support a testimonial from an expert. In this instance, expert evidence can be claimed by both sides, and the sceptic can be confuted by the proof of actual production. At the Crystal Palace exhibition, petroleum drawn from our own rocks was on show, and it might have been any time within the last fifty years. It is the extent of the accumulations that remains in doubt. That oil has been stored in the reservoir sandstones of the Millstone Grit series, and in the porous horizons of the Upper Carboniferous Limestones is more than probable, while the coal measures and Pendleside shale offer an impervious cover to prevent this elusive fluid escaping. But there are also several faults, some of large throw, which may operate adversely, and our attempt to recover the oil may have been made ages too late. It is probable that "adsorption, dissipation of light oil, circulation of water, may have removed all but heavy residues of oil and residual gas, and only relics of impregnation and occasional filtered "shows" will be found." Although the author writes more hopefully of Scotland than of England, as a possible source of petroleum, yet he leaves the impression that large commercial underground supplies of crude oil will not be encountered, even in the localities most favoured by geological structure. Some of the signs which have been advertised as "promising indication," Mr. Craig regards as fairly conclusive evidence that the well (Hardstoft) is a failure, and "it is most unfortunate that undue prominence should have been given in the Press to such a paltry and discouraging show." Further, in Derbyshire, two wells have been continued below the horizons in which alone commercial success is possible. Oil shales, as those of Kimmeridge, and also cannels and torbanites, as well as blackband ironstones and lignites might be turned to account, after the plan adopted in the Scottish shale oil industry, but even if successful this source would hardly compensate for the disappointment arising from the failure to tap generous underground sources of petroleum.

BOOKS RECEIVED.

Files and Filing. Translated under the supervision of GEORGE TAYLOR. From the French "La Lime." By CH. FREMONT. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

United States Geological Survey. No. II: 27. *Coal in 1918.* Part A. *Production.* By C. E. LESHER. Bulletin No. 715–A. *Potash Deposits in Spain.* By HOYT S. GALE. No. 715–B. *The Potash Deposits of Alsace.* By HOYT S. GALE. Professional Paper No. 111. *The Ore Deposits of Utah.* By B. S. BUTLER and others. [Price 1 dol. 50 cents.] Washington: Government Printing Office.

Rendiconti Dell' Istituto Sperimentale Aeronautico Anno VIII. No. 2. Settembre, 1920. [Price 20 lira.] No. 3. Novembre, 1920. [Price 25 lira.] Roma: Tipografia Della R. Accademia Dei Lincei.

Matter and Motion. By J. CLERK MAXWELL, M.A., LL.D., F.R.S.S. L. and E. Reprinted with Notes and Appendices. By Sir JOSEPH LARMOR, F.R.S., M.P. London: Society for Promoting Christian Knowledge. [Price 5*s.* net.]

Instituto Católico de Artes e Industrias. Electrodinámica Industrial, par JOSE A. PERCY DEL PULGAR, S.J. Tomo I. *Teoria General de los Campos de Fuerzas Electromagnéticos.* [Price 8 pesetas.] Tomo II. *Teoria de Corrientes.* [Price 8 pesetas.] Tomo III. *Medidas Eléctricas.* [Price 8 Pesetas.] Tomo IV. *Máquinas de Curriente Continua.* [Price 12 pesetas.] Madrid: Establecimiento Tipográfico de Fortanet.

Export Register of the Federation of British Industries, 1920. London: Industrial Publicity Service, Limited. [Price 25*s.*]

Small Holding and Irrigation. The New Form of Settlement in Palestine. By Dr. S. E. SOSKIN. London: George Allen and Unwin, Limited. [Price 2*s.* net.]

A Course in Electrical Engineering. Vol. I. *Direct Currents.* By CHESTER L. DAWES, S.B. New York and London: McGraw Hill Book Company, Inc. [Price 25*s.* net.]

Advertising the Technical Product. By CLIFFORD A. SLOAN and JAMES D. MOONEY. New York and London: McGraw-Hill Book Company, Inc. [Price 30*s.* net.]

Personal Administration: Its Principles and Practice. By ORDWAY TEAD and HENRY C. METCALF, Ph.D. New York and London: McGraw-Hill Book Company, Inc. [Price 30*s.* net.]

Mine Book-keeping: A Comprehensive System of Records and Accounts for Mining Operations of Moderate Dimensions. By ROBERT MCGARRAUGH, E.M. New York and London: McGraw-Hill Book Company, Inc. [Price 12*s.* net.]

Outlines of Industrial Administration, Based on a Course of Lectures given at Sheffield University. By R. O. HERFORD, H. T. HILDAGE, M.Inst.C.E., and H. G. JENKINS. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

Heat Engines, Embracing the Theory, Construction and Performance of Steam Boilers, Reciprocating Steam Engines, Steam Turbines and Internal Combustion Engines. A Text-Book for Engineering Students. By DAVID ALLEN LOW, Whit School., M.I.Mech.E. London: Longmans, Green and Co. [Price 17*s.* 6*d.* net.]

A Treatise on Aircrews. By WHYRILL E. PARK, A.R.C.Sc. London: Chapman and Hall, Limited. [Price 21*s.* net.]

United States Geological Survey. Professional papers. No. 108–H. *The Pliocene History of Northern and Central Mississippi.* By E. W. SHAW. Washington: Government Printing Office.

Lehrbuch der Mathematik. HERAUSGEGEBEN VON ESSELBORN. Vols. 1 and 2. Leipzig: Verlag von Wilhelm Engelmann. [Price 64 marks + 70 per cent.]

United States Department of Commerce. Bureau of Foreign and Domestic Commerce. Monthly Summary of Foreign Commerce of the United States, January-February, 1920. [Price 10 cents. each.] Washington: Government Printing Office.

United States Bureau of Mines. Bulletin 95. *A Glossary of the Mining and Mineral Industry.* By ALBERT H. FAY. [Price 75 cents.] Technical Papers No. 232. *Absorption as Applied to Recovery of Gasoline left in Residual Gas from Compression Plants.* By W. P. DYKEMA and ROY O. NEAL. [Price 15 cents.] No. 240. *Boiler and Furnace Testing.* By RUFUS T. STROHM. [Price 5 cents.] No. 241. *Blowholes, Porosity and Unsoundness in Aluminium Alloy Castings.* By ROBERT J. ANDERSON. [Price 10 cents.] No. 250. *Metal-Mine Accounting.* By C. B. HOLMES. [Price 10 cents.] No. 252. *Metal Mine Accidents in the United States during the Calendar Year,* 1918 (*with Supplemental Labour and Accident Tables for the Years* 1911 *to* 1918, *inclusive*). Compiled by ALBERT H. FAY. [Price 10 cents.] No. 256. *Accidents at Metallurgical Works in the United States, during the Calendar Year* 1918. Compiled by ALBERT H. FAY. Price 5 cents.] Washington: Government Printing Office.

United States Coast and Geodetic Survey. Terrestrial Magnetism. Serial No. 125. *Alaska Magnetic Tables and Magnetic Charts for* 1920. By DANIEL L. HAZARD. [Price 20 cents.] Washington: Government Printing Office.

United States Geological Survey. Mineral Resources of the United States, 1916. Part I. *Metals.* H. D. MCCASKEY, Geologist in Charge. Part II. *Non-Metals.* E. F. BURCHARD and G. F. LOUGHLIN, Geologists in Charge. No. 1, A. *The Work on Mineral Resources done by the United States Geological Survey.* By EDSON S. BASTIN and H. D. MCCASKEY. No. 1: 13. *Gold, Silver, Copper, Lead and Zinc in Montana in* 1918, *Mines Report.* By C. N. GERRY. I: 14. *Gold, Silver, Copper, Lead and Zinc in New Mexico in* 1918, *Mines Report.* By CHARLES W. HENDERSON. I: 15. *Gold, Silver, Copper, Lead and Zinc in Arizona in* 1918, *Mines Report.* By C. V. HEIKES. I: 16. *Gold, Silver, Copper, Lead and Zinc in Utah, Mines Report.* By C. V. HEIKES. I: 17. *Gold, Silver, Copper, Lead and Zinc in California and Oregon in* 1918, *Mines Report.* By CHARLES G. YALE. I: 18. *Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in* 1918, *Mines Report.* By C. N. GERRY. I: 19. *Bauxite and Aluminium in* 1918. By JAMES M. HILL. I: 20. *Iron Ore, Pig-Iron and Steel in* 1918. By ERNEST F. BURCHARD. I: 21. *Secondary Metals in* 1918. By J. P. DUNLOP. I: 22. *Manganese and the Manganiferous Ores in* 1918. By D. F. HEWETT. I: 26. *Gold, Silver, Copper, Lead and Zinc in Colorado in* 1917, *Mines Report.* By CHARLES W. HENDERSON. I: 27. *Zinc in* 1917. By C. E. SIEBENTHAL. II: 18. *Potash in* 1918. By W. B. HICKS. II: 19. *Asphalt and Allied Substances in* 1918. By C. C. OBDON. II: 20. *Mineral Waters in* 1918. By ARTHUR J. ELLIS. II: 21. *Architectural Concrete Stone and Concrete Blocks in* 1917 *and* 1918. By G. F. LOUGHLIN. II: 22. *Strontium in* 1918. By GEORGE W. STORE. II: 23. *Asbestos in* 1918. By J. S. DILLER. II: 24. *Talc and Soapstone in* 1918. By J. S. DILLER. II: 25. *Cement in* 1918. By ERNEST F. BURCHARD. *With Sections on Imports and Exports in Foreign Countries,* by R. S. SCHULTZ, Junior, *and on Concrete Ships,* by ROBERT W. LESLEY. Washington: Government Printing Office.

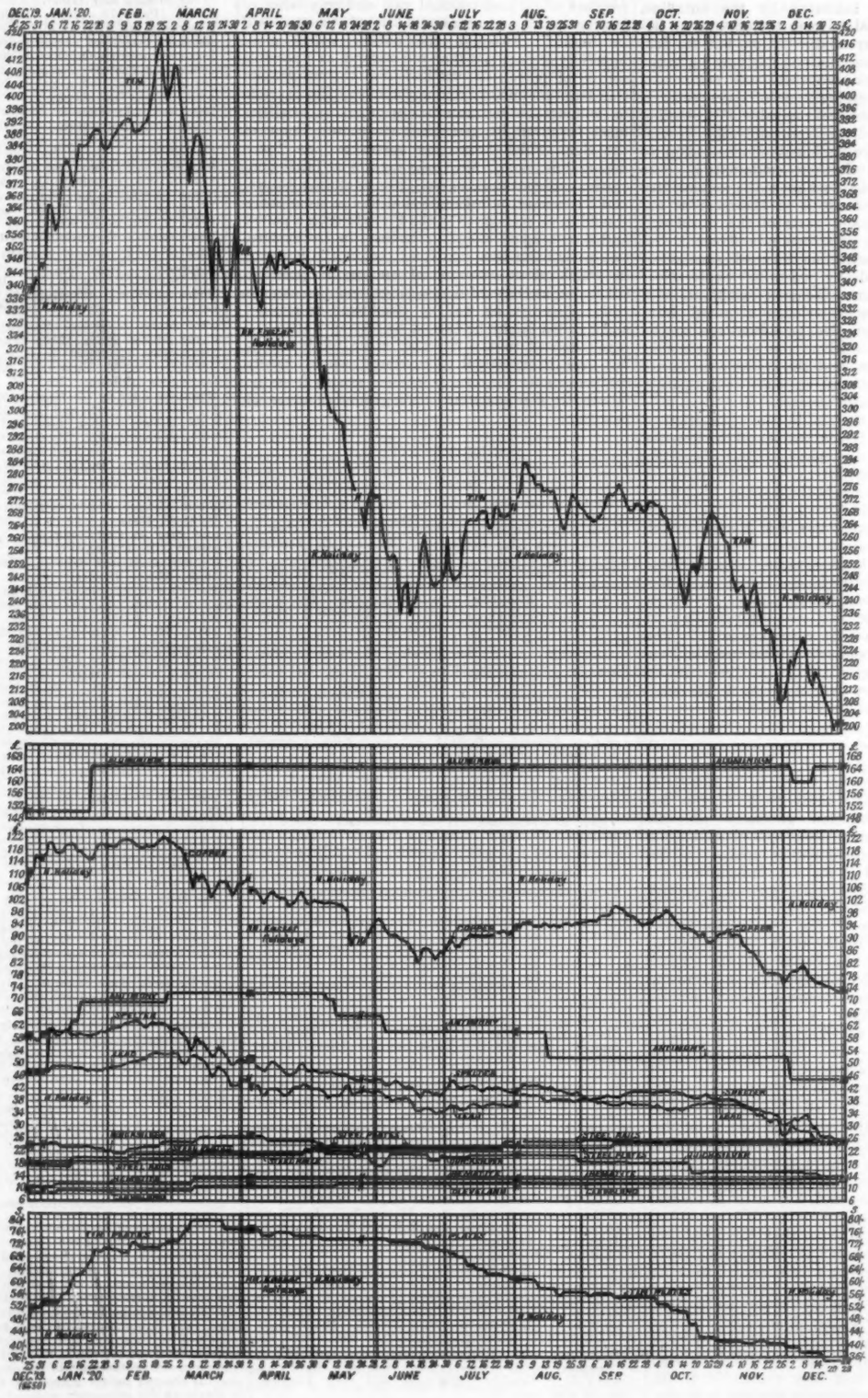
United States Geological Survey. Bulletins No. 695. *The Data of Geochemistry.* By FRANK W. CLARKE. Fourth edition. No. 710–F. *Deposits of Manganese Ore in Nevada.* By J. T. PARDEE and E. L. JONES, Junior. No. 711–E. *Gas in the Big Sand Draw Anticline, Freemont County, Wyoming.* By A. J. COLLIER. No. 711–F. *The Abram Creek-Stony River Coal Field, Northeastern West Virginia,* By GEORGE H. ASHLEY. No. 711–G. *Geology and Oil and Gas Prospects of the Huntley Field, Montana.* By E. T. HANCOCK. Washington: Government Printing Office.

United States Geological Survey. Water Supply Papers No. 401. *Surface Water Supply of the United States,* 1915. Part I. *North Atlantic Slope Drainage Basins.* [Price 15 cents.] No. 439. 1916. Part IX. *Colorado River Basin.* [Price 15 cents.] No. 444. 1916. Part XII. *North Pacific Slope Drainage Basins.* C. *Lower Columbia River Basin and Pacific Slope Drainage Basins in Oregon.* [Price 15 cents.] No. 448. *Gazetteer of Streams of Texas.* Prepared under the direction of GLENN A. GRAY. [Price 20 cents.] Washington: Government Printing Office.

THE EFFECT OF CHARRING ON THE PRESERVATION OF WOOD.—According to the Forest Products Laboratory of the United States the charring of fence posts and telegraph poles does not delay rotting. In most cases charred posts decayed more quickly than uncharred. The argument in favour of charring is that charcoal is not liable to be injured by living organisms or by oxidation. Even accepting these very dubious assumptions, however, the charring must not be thorough and complete, because it would weaken the wood too much, and if it be superficial and incomplete, the protection will be questionable. When the wood is charred before seasoning, the covering will open in places as the seasoning proceeds, and when the wood is seasoned before charring, the charring may not penetrate deep enough. As regards mine timber, the advisability of some impregnation to prevent decay is insisted upon. In Alabama creosoting has answered very well; all the timber treated with coal-tar [creosote] was still sound after 10 years. The objection to creosote is the fire risk. Sodium fluoride and zinc chloride somewhat diminish fire risks and are odourless.

DIAGRAMS SHOWING FLUCTUATIONS IN THE PRICES OF METALS FROM CHRISTMAS, 1919, TO CHRISTMAS, 1920.

Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.



NOTE.—In the above diagram the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough quotations are plotted for steel plates and steel rails and also for hematite and Cleveland pig irons. The price of tin plates is per box of I.C. cokes free on board at Welsh ports, but the prices of all other metals are per ton. Each vertical line in the diagram represents two market days, and the horizontal lines represent 2*l.* each, except in the case of tin plates where they represent 2*s.* each.

RADIOLOGY APPLIED TO THE TESTING OF MATERIALS.*

By A. P. M. FLEMING, C.B.E., M.Sc.(Tech.), M.I.E.E., and J. R. CLARKE, M.Sc.

(*Concluded from page* 152).

4. *Measurement of X-rays.*—The output of an X-ray tube may be specified in respect to the intensity, and the hardness, or the quality, or penetrating power of the rays. The intensity of the X-rays at a particular point is defined as the energy falling on one square centimetre of receiving surface containing the point, the receiving surface being placed at right angles to the rays. To measure this all the rays received by the surface must be absorbed. There are several methods of measuring intensity. The one most usually employed in X-ray practice is based on the fact that for a given voltage the intensity of radiation is proportional to the current through the tube, so that in photographic work the operator judges the exposure by the milliamperage passing through the tube.

In the therapeutic use of X-rays the intensity is measured by the colouration of various prepared pastilles. These are standardised, so that they assume a definite tint when a specified amount of energy has been received by them. The earlier workers used photographic or fluorescent methods of measuring intensity. A photographic plate or a fluorescent screen, however, does not absorb all the incident rays, so that undue weight is given to the softer, more easily absorbed rays when a heterogeneous beam is used.

The heat developed when X-rays are absorbed affords another means of measuring intensity, but it is so small that the method is not suitable for ordinary work. In the case of a gas the production of heat is preceded by ionisation. This is the basis of the method of measurement which is most frequently employed in scientific work. The rays are passed into an ionisation chamber where they are completely absorbed, and the ionised gas is subjected to an electric field strong enough to carry all the ions to the electrodes as soon as they are formed. When this happens the current passing is a measure of the number of ions produced by the rays.

The penetrating power of rays varies with the e.m.f. applied to the tube. It has been seen, however, that even when the voltage applied is constant the resulting X-rays are not homogeneous, and the sinusoidal voltages give rays of the same quality as a continuous constant variation, at any rate up to about 70,000 volts. It is probable, therefore, that it is only the maximum penetrating power which is a function of the voltage. Nevertheless, it is desirable that this should be measured, and for this purpose a spark gap is usually employed in parallel with the tube. This so-called equivalent spark gap gives a measure of the potential difference employed.

Owing to the difficulty of maintaining a gas tube at a definite vacuum it has become customary to express the hardness or penetrating properties of the rays in some other way than that of the voltage used. The most common practice has been to measure the absorption of the rays by aluminium, and the hardness is often expressed in terms of the thickness of aluminium required to reduce the intensity to half, or by a definite amount. Many penetrometers have been devised to work on this principle, an example being the Benoist penetrometer which is described in Appendix I.

The methods of expressing the quality of the rays which are emitted from an X-ray tube are somewhat arbitrary, however. X-rays have been compared with light, and just as the most definite method of referring to a particular kind of light is to state the wave lengths of its components, so the best way of describing the character of a beam of X-rays is to state the wave-lengths of the constituents which make up the beam. The measurements of these wave-lengths is, however, very difficult, and cannot be made as a routine operation when materials are being examined.

X-Ray Examination of Materials.—As already pointed out an X-ray photograph is simply a shadow picture formed when X-rays pass through a substance of varying density, and chemically affect the silver bromide of the photographic plate placed behind the object thus penetrated. The following considerations apply in X-ray photography :—

The arrangement of the photographic film or plate relative to the object to be examined and the X-ray tube.

The protection of the plate against secondary rays.

The protection of the operator against the effect of X-rays.

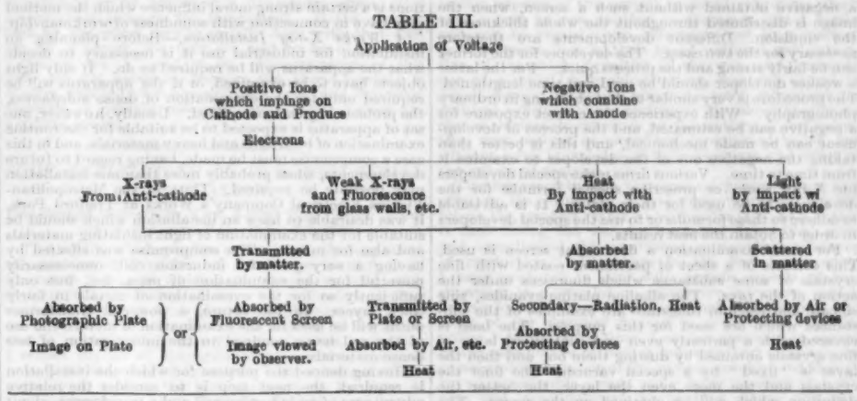
The character of the plate or film used and intensifying screens.

Fluorescent screens for visual examination with suitable reflecting mirrors.

In connection with the production of X-rays it was stated that the cathode was concave so that the cathode rays were focussed on the anti-cathode. Thus the X-rays should proceed from a point, but this does not occur in practice, the focal spot usually being a circle 2 mm. or 3 mm. in diameter. The shadow cast by a body opaque or translucent to the rays is, in consequence, not sharply defined, but has a region of partial shade corresponding to the penumbra in shadows cast by light, and the photographic plate must, therefore, be as near as possible to the anti-cathode, the source of the rays, in order to reduce the area of this region. Further, in order to avoid distortion the rays should pass perpendicularly through the object to the plate, and to obtain the maximum intensity the central ray should pass through the centre of the object.

* Paper read before the Manchester Association of Engineers, on Saturday, December 11.

TABLE III.



The secondary X-rays and Beta-rays (see Fig. 10) which are emitted in all directions when X-rays are incident on a metal, from the metal itself, are probably characteristic of all matter and not of metals only, but in the case of lighter substances the intensity of this radiation is so small that its effect is negligible. The

Fig.10. SECONDARY RAYS

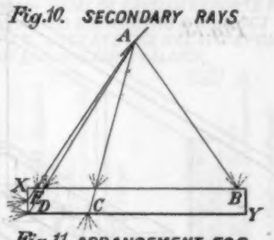
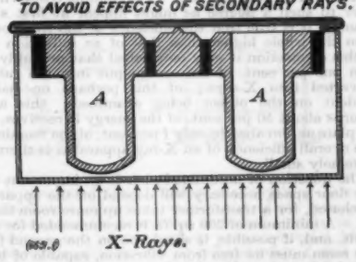


Fig.11 ARRANGEMENT FOR TAKING PHOTOGRAPH IN SECTION.

Fig.12. METHOD OF MOUNTING SPECIMEN TO AVOID EFFECTS OF SECONDARY RAYS.



secondary rays that are generated in the interior of the mass are absorbed by the surrounding substance, but not so those that are produced at the surface. Thus, if the photographic plate is placed in contact with the object to be radiographed, without any precautions being taken to eliminate these rays, the outlines of the image obtained will be blurred and the plate may even be completely fogged. It is not necessary to take precautions against secondary rays in medical radiography owing to the small intensity of these rays, but it is essential in the examination of metals.

Where the object to be radiographed is flat and continuous there is no difficulty, for the plate can be surrounded with lead except where it is in contact with the object (see Fig. 11, which shows the arrangement for the examination of a specimen). It is preferable to have the surface of the lead next the plate covered with sheet aluminium (about 0·2 mm. thick), to absorb the secondary rays from the lead; the secondary rays from the aluminium are weak and will not produce appreciable fogging. If the object is irregularly shaped the shielding of the plate from the secondary rays is more difficult, and the operator's own experience must guide him. Mercury and paraffin wax are very useful in this connection. For example, an object with the section shown in Fig. 12 may be mounted as indicated. It is embedded in paraffin wax contained in a cardboard box; the bottom of the screw holes are filled with mercury, the tops with paraffin wax; the spaces, A, are also filled with paraffin wax. The photographic plate is placed on top of the object to be examined.

It has been noted above that the potential difference applied to the electrodes of the tube affords a measure of the penetrating power of the resulting rays, and the milliameter indicates the intensity. The exposure of a plate is, therefore, usually stated in terms of the equivalent spark gap, milliamperes of current, and the time in seconds. The intensity, however, varies as the square of the distance from the anti-cathode, and the distance between the plate and the target is, therefore, another quantity which must be stated to make the record complete. This last distance is usually about 15 in., and so, working with a constant spark gap, say, 12 in., the exposure can be expressed in milliampere seconds. The length of the spark gap affects the quality of the negative, the contrast decreasing as the spark gap increases. It is advisable, therefore, to use as short a spark gap as possible, though this should not be shortened to such an extent that the exposure is unduly prolonged. Otherwise the effect of the secondary rays, which are present, however well the plate is shielded, will be very great.

The protection of the operator is of the utmost importance for the reasons already given. Protection is usually afforded by enclosing the X-ray tube in a box having a lining of lead of not less than $\frac{1}{4}$ in. in thickness, which will diminish the destructive effect of the hardest X-ray tube to a degree that is harmless to the operator. Further protective arrangements will be dealt with later.

When X-rays are incident on an ordinary photographic plate only a fraction of 1 per cent. is absorbed, and even with plates prepared with special emulsion the absorption is still less than 1 per cent. Thus the greater part of the energy of the beam of rays is wasted. This, in turn, is only a small portion of the original energy expended in the electrical discharge, as will be seen from the diagram, Table III.

To increase the proportion used recourse has been had to "intensifying screens." An intensifying screen is merely a fluorescent screen of calcium tungstate placed in direct contact with the emulsion of the photographic plate. In such an arrangement the image on the plate is caused mainly by light from the screen, and is, therefore, situated most on the surface of the emulsion. In practice, intensifying screens are mounted in *cassettes* or rigid holders, in order to ensure perfect contact between the emulsion and the screen. Their use enables the exposure to be cut down to less than one-fifth of that necessary when such a screen is not employed. The exposures necessary in X-ray photography have also been reduced by the invention of "duplitised" films. These are gelatinous films coated on each side with the sensitive emulsion. With the use of a duplitised film and two intensifying screens—one for each emulsion surface—radiographs of the human body have been taken in one-thousandth of a second.

For mild steel, with a 15 in. equivalent spark gap, the film placed 15 in. from the anti-cathode, the following are the approximate exposures necessary :—

TABLE IV.

Thickness. in.	Exposure. Milliampere-seconds.
0·2	32
0·5	120
1·0	500
1·5	1,200
2·0	2,500

For the above exposures a standard Coolidge tube and a duplitised film with the two intensifying screens were used. In ordinary practice the spark gap would not be maintained constant for all these thicknesses, but would be increased with the thickness of the steel. The values serve to indicate the magnitude of the exposure, however.

X-ray plates are not entirely superseded by the duplitised film, nor is the intensifying screen invariably used. When radiographs of light substances, such as mica or fibre, are desired, plates may be used. They are very convenient, being enclosed in light tight envelopes ready for use, and they are also less costly. Films emulsified on one surface are also available and are frequently used, their flexibility being often advantageous.

While in a photograph taken with the aid of an intensifying screen the image is chiefly situated in the surface of the emulsion, exactly the reverse is the case in

a negative obtained without such a screen, when the image is distributed throughout the whole thickness of the emulsion. Different developments are therefore necessary for the two cases. The developer for the former can be fairly strong and the process quick. For the latter a weaker developer should be used and time lengthened. The procedure is very similar to that obtaining in ordinary photography. With experience the correct exposure for a negative can be estimated, and the process of development can be made mechanical, and this is better than taking the negative out of the developer to examine it from time to time. Various firms make special developers for X-ray work, or prescribe special formulæ for the developers to be used for their plates. It is advisable to adhere to these formulæ or to use the special developers in order to obtain the best results.

For visual examination a fluorescent screen is used. This consists of a sheet of parchment coated with fine crystals of some substance which fluoresces under the action of the rays. The alkaline platino-cyanides, zinc silicate and calcium tungstate are examples of the substances which are used for this purpose. The base is covered with a perfectly even and continuous layer of fine crystals obtained by dusting them on, and then the layer is "fixed" by a special varnish. The finer the crystals and the more even the layer, the better the definition which will be obtained on the screen. The screen is usually mounted on a sheet of lead glass to absorb some of the rays which pass through the screen and would otherwise be received by the operator. It should be kept dry and cool, for if it is heated the crystals may lose their water of crystallisation and cease to fluoresce, and if it is allowed to absorb moisture it may expand and become warped. The crystals suffer from "fatigue" after prolonged exposure to the rays, that is, they cease to fluoresce so brightly. They recover to some extent when rested, but are never so good as when first made.

If the thickness of the object to be examined is so great that the rays are very largely absorbed the screen will only fluoresce faintly, and small variations in the absorption will not be easily recognisable. Visual examination, therefore, is only used for thin sheets of dense materials or for moderately thick specimens of lighter substances. The arrangement usually employed is to have the X-ray tube in its special box underneath a table the top of which is very transparent to the rays. The object to be examined is placed on the table and the fluorescent screen is mounted above this. The room in which the operation is carried out must, of course, be darkened. This method of examination is widely used.

Industrial Applications.—The use of radiology in surgical work, especially during the war, is too well known to need further reference here. Industrial applications may be classed under two general divisions, viz., one in which X-rays are employed as a primary and conclusive means of examination, the other in which they are used in a secondary sense in order to confirm or supplement some other method of examination.

The first of these includes a variety of miscellaneous uses, among which are the following :—

The examination of oysters for pearls, this being one of the first industrial uses to which X-rays were put.

The examination of imitation lead glass jewellery, which by means of X-rays can be distinguished from genuine jewels, due to the fact that they are more opaque to the rays.

The examination of golf balls to see whether the core is central.

The examination by Revenue officials of parcels for contraband.

The examination for soundness of timber and timber fittings in aircraft work.

The examination of insulating materials such as vulcanised fibre, micanite sheet, &c., to detect presence of conducting particles.

The examination for blow-holes and defects in light castings, the soundness of welded joints, the accuracy of assembled parts of mechanisms.

The examination of the interior of moulded articles such as insulated parts containing metal fixtures.

The determination of extent to which cable junction boxes are completely filled.

The difference between carbon steels and tungsten or other steels having an ingredient of very high atomic weight. In this connection it may be noted that while the marking of an original billet may clearly indicate the difference in such steels, parts that have been machined from the billets lose their original identity. This may be re-established by X-ray examination. Many other general uses may be found, such as in connection with the special ferro-concrete parts.

The use of X-rays for testing in a secondary sense applies in such cases, especially as the examination of forgings where any incipient flaws or blow-holes have been compressed until they appear almost as a hair line. Such defects are hardly likely to be detected by X-rays unless the crack is parallel to the line of the rays or the amount of metal penetrated by the rays is such that the crack represents an appreciable part of the total thickness. In the case of turbine discs, X-rays may be very valuable in those border line cases where the examination of the surface shows defects which may or may not penetrate through the entire thickness of metal, and which cannot be assumed to penetrate even where opposite phases of the disc show evidence, for instance, of sponginess or slag inclusion or segregation. These indications may be only superficial, and where the thickness of steel is not greater than 1-in., the examination of the defective areas by X-rays compared with sound portions may afford sufficient information to determine the acceptance or rejection of the disc. Many such cases may be found where their use forms a very useful supplement to existing means of testing by examination. An important aspect of X-ray examinations is a certain strong moral influence which the method may have in connection with soundness of workmanship.

A Works X-ray Installation.—Before planning an installation for industrial use it is necessary to decide what the apparatus will be required to do. If only light objects have to be examined, or if the apparatus will be required only for the examination of dense substances, the problem is greatly simplified. Usually, however, one set of apparatus is expected to be suitable for the routine examination of both light and heavy materials, and in this case a compromise must be made, having regard to future developments, when probably more than one installation may possibly be required. Thus, at the Metropolitan-Vickers Electrical Company's Works at Trafford Park, it was desirable to have an installation which should be suitable for the examination of light insulating materials and also for metals. The compromise was effected by having a very powerful induction coil, unnecessarily powerful for the examination of mica, &c., but only sufficiently so for the examination of metals in fairly thick layers. In the future, a powerful transformer outfit will be used for the examination of metals, the use of the coil being confined to the investigation of less dense materials.

Having defined the purpose for which the installation is required, the next step is to consider the relative advantages of an induction coil and a transformer, about which there is considerable difference of opinion.

The general view seems to be held that for continuous production of a heavy discharge, such as is required in the routine examination of metals, a transformer is preferable, but for intermittent short exposures, as in the radiography of light materials, an induction coil is equally if not more satisfactory. The initial cost is a consideration that must almost inevitably play a part in the final decision. The induction coil is much cheaper than the transformer. If cost is not such an important factor, and the outfit is to be used for metallography alone a transformer is recommended. The running costs will not differ to such a degree as might appear at first sight, although it is true that the efficiency of the transformer is on the whole higher than that of an induction coil. In this connection it may be recalled that probably less than one per cent. of the energy put into the tube is converted into X-rays; of this perhaps one-half is incident on the object being examined; this again absorbs about 50 per cent. of the energy it receives, and the plate or film absorbs only 1 per cent. of the remainder. The overall efficiency of an X-ray apparatus is therefore extremely small.

The question of accommodation is an important one. The floor space necessary will depend on the apparatus purchased, for a transformer takes up more room than a coil. A minimum of 200 sq. ft. is recommended for each outfit, and, if possible, it should be on the ground floor. The room must be free from vibration, capable of being completely darkened, and at the same time well ventilated. The arrangement of the apparatus in the room selected will be largely influenced by the precautions taken for the safety of the operator. This is most important, not only as already noted on account of the destructive effects of X-rays on human tissues, but also to protect the operator from accidental contact with high voltage wiring. The suppliers of the apparatus will advise on the question of such protection. A box lined with lead to a thickness of half an inch should be provided in the laboratory for the purpose of storing plates. Only a small supply should be kept in this box, as, even with half an inch of lead, some rays will penetrate to the plates.

A typical arrangement of works' X-ray equipment is shown in Fig. 13.

The following is a general specification of an X-ray installation, assuming that an induction coil is to be used.

1. One induction coil to work on a 250 volts supply. The primary to be subdivided into two layers. The secondary to be capable of yielding a 20-in. spark between needle points. When tested with a dry tungsten target tube, using a 10-in. equivalent spark gap, with a current not exceeding 12 amperes passing through the primary, an output of not less than 20 milliamperes will be required. Suitable condenser and primary coil terminals to be provided for connection by cable to the interrupter.

2. One motor-driven interrupter of the mercury jet type, for use with the above coil. The dielectric to be used will be coal gas, and the container must be gas tight. The adjustment of the motor and interrupter must not be disturbed when the top is removed for cleaning.

3. One mechanical rectifier, mounted on ball bearings and fitted to the above interrupter.

4. One trolley switch-table, with marble top, fitted with an ammeter, pilot lamp, main switch, lamp switch, interrupter switch, regulator for coil primary resistance, regulator for interrupter circuit resistance, fuses, insulated connecting terminals and iron frame carrying resistance units.

5. One sphere and spark-gap, for placing in parallel with the X-ray tube. The spheres to be of copper, 10 cm. in diameter, and being capable of measurable adjustment up to 20 cm. apart.

6. One transformer control, for heating the filament of a Coolidge tube, consisting of an oil-insulated statie transformer, ammeter and fine and coarse regulators by transformer control, for use on a 110 volts supply, this apparatus to be properly insulated for high tension.

7. One wooden table, with top transparent to X-rays.

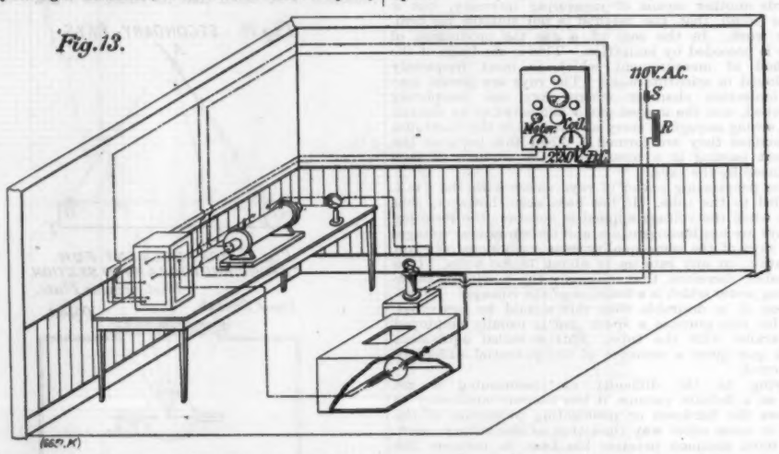
8. One lead-covered tube box, totally to enclose Coolidge tube. Fitted with centering tray, lead glass window and inspection mirror, rectangular diaphragm, and insulated leading-in tubes.

9. One standard Coolidge X-ray tube with medium focus.

10. One fluorescent screen, 12 in. by 9 in., of "White Salt," with protective handles and lead glass backing.

11. Four intensifying screens and exposure cases, 12 in. by 10 in., 10 in. by 8 in., 8½ in. by 6½ in., 6½ in. by 4¼ in.

Fig. 13.



12. One lead-lined box for storing X-ray plates, measuring 18 in. by 12 in. by 12 in. internal dimensions, the lead being ⅛ in. thick.

13. All necessary connections, cables, etc., for the above apparatus.

Conclusions.—Having considered how X-rays are produced and how their properties can be turned to practical account, some attention may be given to the future possibilities of usefulness in the examination of materials.

Industrial applications can be extended through the improvement in three directions of :—

(*a*) Methods of production of X-rays.

(*b*) The manner in which the effects of X-rays can be appreciated by our senses.

(*c*) Technique.

All these ways are the subject of research by many workers, and notable advances may be expected in all three directions.

The work of improving the production of X-rays falls into two classes, firstly, the lowering of the cost of the producing apparatus, and secondly, the technical improvement in the means producing X-rays, whether in generation of high voltage or in improvements in the X-ray tube.

The effect of the wave shape of the applied voltage is still obscure, and further investigation is necessary before any particular method of generating voltage can be said to be the best. At present there are three possible practical sources of high voltage, namely, the induction coil, transformer, and some form of continuous voltage generator. The voltage which can be obtained from the first of these sources is restricted by insulation defects, but progress may be made in this direction, and if such wave shape as that yielded by an induction coil should prove to be the one most desirable, coils having much higher power than those at present constructed would no doubt be forthcoming. The induction coil, however, on account of its open magnetic circuit, is somewhat inefficient, and the transformer is gaining in favour. In this case the problem is how best to rectify the alternating wave shape. Mechanical rectifiers are at present most usually employed, but the development of the thermionic valve may cause the replacement of this means of rectification by a bridge of such valves. Research may evolve other suitable means of rectification.

The X-ray tube is still extremely inefficient, and, despite the research of Dr. Coolidge and others, no tube has yet been made capable of withstanding the highest voltages that are available. Improvements in the X-ray tube afford the greatest possibilities for the extension of the application of the X-ray to industrial

problems, and the tube of the future may be as radically different from the Coolidge tube as this is from the gas-tube. It is of interest to note that in this country transformers from upwards of 300,000 volts are being constructed for X-ray work, and it is expected that X-ray tubes will also be forthcoming for use with such voltages.

The next direction in which advances may be made is in the improvement of photographic devices and fluorescent screens. Manufacturers of photographic materials are fully alive to the possibilities of progress in this direction, as the introduction of duplitised films and intensifying screens testifies. But much remains to be done, as only a small portion of the rays reaching the plate or film contributes to the formation of the image. Other methods may be developed of detecting the presence of X-rays after penetration of the object under examination, possibly by developments involving the use of selenium, whose resistance varies when subjected to rays.

There remains the problem of improving technique—in particular, in the types of cassettes used, in the shielding of the photographic plates from secondary rays, and in the protection of the operator. In all these matters the aim should be to make X-ray photography as simple as light photography, and as far as possible all the lines of advancement should be contemporary.

While the progress made in recent years in the application of the examination of materials has been extremely rapid, the limitations inherent in the methods of examination by Röntgen rays must not be lost sight of. For instance, at least 2,000,000 volts would be required to produce X-rays as penetrating as the Gamma rays of the radiograph. Assuming that rays of this penetrating power were formed, all but a small fraction, say, of about 3 per cent., would be absorbed by 6 in. thickness of lead. Thus it is unlikely that it will ever be possible to examine metals greater in thickness than those corresponding to the degree of absorption. Moreover, even if 2,000,000 volts were available, the speed of the cathode rays producing the X-rays would approximate to that of light, and serious complications might arise in the tube, and prevent the formation of X-rays. Even with rays of greater penetrating power it will still be extremely difficult to detect minute flaws in large thicknesses of metal, and, as pointed out in this connection, X-ray examination will only be of secondary assistance to some other means of detecting the probable presence of such flaws.

While the hopes built upon the X-ray examination of materials, apparently so promising on first consideration, are hardly ever likely to be fulfilled, especially in respect of those defects whose presence is fraught with so much risk in highly-stressed materials, the method is of very great importance and is proving its worth as a general means of investigation, and engineers will do well, even if they are not justified in establishing X-ray installations at their own works, to keep informed of progress made and become familiar with the technique involved in the application of radiology to material testing.

APPENDIX I.

THE MEASUREMENT OF X-RAYS.

(*a*) *Intensity.*—The first attempt to lay down a standard of intensity was made by the Röntgen Society in 1909. They suggested that the intensity of the rays from an X-ray bulb should be compared with the intensity of the Gamma-radiation from a definite quantity of radium. In 1910 an international standard was adopted. It is a specimen of pure radium chloride weighing 21·99 milligrammes. The ionisation produced by the radiation from an X-ray tube can be compared with the ionisation produced by this standard when placed an equal distance away. This method of measurement is quite arbitrary, and it is better to adopt one of the ways given in the paper if accuracy is required. With the Coolidge tube the problem is greatly simplified. The current through the tube can be adjusted by varying the current through the cathode filament, and the intensity of the rays is proportional to the current through the tube. Kranche gives the formula $I = k_i (V^2 - V_0^2)$, where I is the intensity of the rays, i the current, V the applied voltage, and V_0 and k are constants for the tube. Thus the milliameter in the secondary circuit affords a measure of the intensity of the radiation.

(*b*) *Penetrating power.*—The equivalent spark gap should be measured between spherical electrodes. For voltages up to 100 kilovolts the spheres should be 5 cm. in diameter; if voltages greater than this are to be employed, 10 cm. spheres should be used. A complete calibration of the spark gap will be supplied by the makers, but the following table gives a few values of the sparking distance in normal air:—

Electrodes.	Voltage kilovolts.	Spark gap cms.
5 cm. spheres ...	20	0·6
" " ...	50	1·71
" " ...	70	2·68
" " ...	100	4·77
10 cm. spheres ...	100	3·75
" " ...	150	6·64
" " ...	200	11·2

The absorption method of measuring penetrating power is based on the uniform absorption of the rays according to the law $I = I_0 \epsilon^{-\lambda d}$. I is the intensity of the rays after passing through a plate of thickness d cms., I_0 is the incident intensity, and λ a constant — the *linear absorption* coefficient of the substance. This varies with the density and atomic weight of the substance, and the variation is used in the construction of penetrometers. Benoist's penetrometer consists of a circular disc of silver 0·11 mm. thick, surrounded by 12 numbered aluminium sectors of thicknesses ranging from 1 to 12 mm. The X-rays are examined photographically or by means of a fluorescent screen after transmission through the instrument. If the shadow cast by the silver disc is equally dark with that cast by No. 5 sector, the rays are said to be of hardness "Benoist No. 5," and so on. Penetrometers of this type are not accurate, because the above formula is strictly true only for homogeneous rays, and improved methods of quickly measuring penetrating power are urgently needed.

SOME REFLECTIONS ON OUR INDUSTRIAL SITUATION.

Presidential Address by THE RIGHT HON. LORD WEIR OF EASTWOOD, P.C., D.L., LL.D.*

THE honour which you have done me in electing me to the position of President of the Junior Institution of Engineers is one of which I am deeply sensible, and, coming from members of my own profession, I may confess it gives me more than usual pleasure and gratification. At the same time, I do not fail to recognise that it carries with it heavy responsibilities, and when I review the list of distinguished men who in the past have filled the office of President, I am conscious of my inability to achieve the high standard set by them in their addresses to you. However, I yield to no one in my appreciation of the honour you have conferred on me in electing me to this important office, and my ambition and endeavour shall be to support and encourage by every means in my power the many valuable activities of the Institution.

Fig. 1. MAIN ITEMS OF BRITISH EXPORTS FOR YEAR 1913 & 12 MONTHS ENDED OCT. 1920 TO ILLUSTRATE THE RELATIVE POSITION OF ENGINEERING (VALUES).

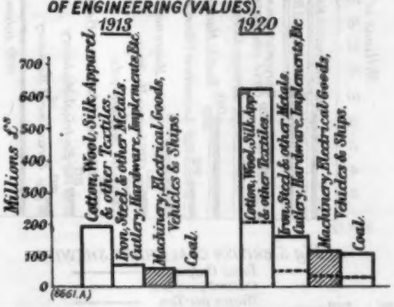
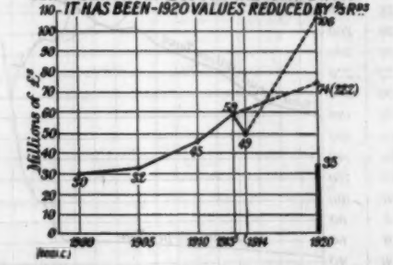


Fig. 3. PROGRESSIVE EXPORT CHART OF MACHINERY, SHIPS & VEHICLES SINCE 1900 ILLUSTRATING WHAT 1920 WOULD HAVE BEEN ON OUR ORDINARY RATE OF PROGRESSION & WHAT IT HAS BEEN—1920 VALUES REDUCED BY 5/8RDS

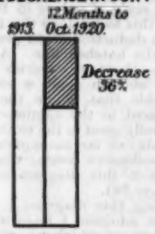


In seeking a subject or text for this address, I find myself precluded from offering you anything of value of a technical character, on account of my somewhat protracted divorce from the technical details of our profession; and when I turn to the commercial, industrial and economic aspects of our industry, I find that in past years these matters have been very fully dealt with by my predecessors, in particular by Mr. F. W. Lanchester, who, during the war, in 1918, concluded one of his addresses thus: "The fact that Britain to-day is sailing through a period of stupendous difficulty without apparently any loss of buoyancy must not be taken by those who seek the truth as evidence that there are no breakers ahead. We are, unfortunately, purchasing much of our present immunity from trouble at the expense of the future, and the question for the future is whether we shall have, as a nation, the patience and fortitude to manfully meet the reckoning."

Now, I am conscious that at no previous time in history were we faced with an industrial situation of such deep gravity as obtains to-day, and accordingly I make no apology for attempting to contribute some few crude reflections on the situation which was so accurately forecast by Mr. Lanchester. We are, indeed, entering now on the period of reckoning, and on engineers and technicians will largely depend the nation's capacity to fulfil its responsibilities. However, it is from institutions such as this, wherein the whole atmosphere is symbolic of that spirit of co-operation and frank interchange of view which is primarily essential if an ordered industry is to be realised, that analysis and suggestion should emanate. I regret that it is impossible in dealing with certain aspects of the subject to avoid references which may appear to you political in character, but I would ask you to regard these references not in a narrow partisan sense, but in their broad national application. One of the many penalties of the war, and certainly one of a most far-reaching nature, was the extent to which purely industrial questions were influenced by political considerations, and many decisions having an almost deplorable influence on the welfare of our industries were arrived at under well-intentioned belief, but without a full knowledge of their incidence and effect in the sphere of practice.

Turning recently to a Government paper written just prior to the Armistice, I find these words: "In the future the greatest regret we will suffer from as a nation is that during the war we bargained for, trifled with, and complicated the conditions surrounding efficiency of production." Elsewhere in the last few months I have ventured to deal with certain aspects of this situation, in particular on restrictive influences contributing to inefficiency of our national productivity, and some of the essential factors in a practical remedial policy. At the same time, I am no pessimist in regard to the possibilities of British industry, and although the present position is one of the utmost gravity, and though by no conceivable means can a large measure of hardship and unemployment be avoided during the next two years, a more general appreciation of the fundamental factors governing the position can, and I have every confidence will, enable British industry, through its inherent assets of character and capacity, to regain stability and a future of comparative prosperity.

Fig. 2. BRITISH ENGINEERING EXPORTS IN 1913 & IN 12 MONTHS ENDING OCT. 1920 IN TONNAGE TO SHEW THE DECREASE IN OUR FOREIGN TRADE.



This Diagram includes all Machinery except Electrical Goods and includes Vehicles and Ships.
(6661.B.)

Let me, then, briefly outline the situation as we find it to-day, with particular regard to the engineering industry, always bearing in mind that in such an industry there is a definite time lag in its response to the fluctuations of industry as a whole. On the commercial side we find a definite decrease in inquiries for our products and a still more definite decrease in the number of settled contracts. There is an acute lack of confidence and of healthy enterprise. Foreign competition is again becoming a prominent factor in our consideration. On the production side, which is the most vital of all, the cost of production continues to increase. On the financial side we find restriction of credit to industry, coupled with the necessity for additional capital to meet the higher level of costs. The purchasing power of our foreign customers is low, and the handicap of harmful rates of exchange is almost overwhelming. On the socio-industrial side we have the inevitable corrollary to the foregoing, of increased unemployment and the certainty of a still greater increase. The high cost of living continues to be maintained, and remains one of the most prominent factors in regard to labour unrest. Finally, associated with all these phenomena, our Government finds itself faced with a grave position of national finance and a steadily decreasing productive field for taxation to meet national requirements.

In a general sense we attribute all this to the influence of the war, the upheaval of thought, and the dislocation of policy. But, going further, we can conveniently divide the causes which have produced and continue to influence the situation into those of a material nature and those of a moral or psychological nature. To counteract these influences we necessarily require an intelligent appreciation of them, and of the facts involved in them, before any new national spirit can be created; and in the creation of this spirit we need, above all, sincerity in facing the facts and promptitude in dealing with them. In searching for the truth we must avoid confusing symptoms with causes, because never was it more essential to get right down to fundamentals. The main object of my remarks is to suggest a concentration in each industry on the controlling factors which govern efficiency, volume and cost of production, so that they may be clearly recognised, and the taking of remedial action thereby accelerated.

Let me, then, commence in the sphere of material factors by illustrating to you certain examples of everyday phenomena; and in the first place let us establish the present relative importance of engineering in the world of British industrial activity. Unfortunately, we possess no census of British production, and I am consequently compelled to use our export figures as a guide. It is probable that this consideration in "terms of exports" is the most valuable and suggestive to us in the present situation, because the foundation of our British economic stability must always be our export trade. Fig. 1, above, and Table I, page 881, show the exports of the main classifications of British commodities in 1920 on the basis of to-day's values, and the similar position

* Delivered before the Junior Institution of Engineers, on December 17, 1920.

in 1913 on the values of that date. When I speak of 1920 I mean the twelve months up to and including October, 1920. Included in engineering are the following different classes of product :—

Ships and boats, including their machinery.
Motor-cars, commercial vehicles, and parts ;
Railway passenger carriages, wagons and trucks ;
Locomotives (steam and others) ;
Textile machinery ;
Sewing machines ;
Prime movers, not electrical ;
Machine tools ;
Electrical machinery ;
Boilers and boiler-house plant ;
Agricultural machinery ;
Other and unspecified machinery.

Infinite harm has been done by careless reference to these export figures by using them to show how comparatively well we have done since the Armistice. As the figures show value and not quantity, conclusions have been drawn which obscure the real position, and to-day, with unemployment rife, we must look on the real figures of actual production, and base our policy on repairing the situation they disclose. Accordingly, Fig. 2 shows the relative tonnage, or quantity of engineering exports, in the two years in question, and discloses a fall in engineering exports of 36 per cent. Fig. 3 gives a progressive chart since 1900, showing the normal position which might reasonably have been expected had there been no war. The figures are given in Table III, on page 881. It is apparent that, as engineers, we are not contributing our previous share of payment for imported food and raw material, and in a narrow sense we cannot afford to live at our pre-war standard. Fig. 4 shows the detailed composition of our engineering exports in the two years in question. The diagram is prepared on a scale of values in 1913 (shown in black), and to enable this to be done the 1920 values have been corrected by a deduction of 66 per cent., and the value is shown by the hatched line. As you will note, only in two classes—those of sundries and machine tools—have we been able to avoid a considerable falling off. It is remarkable that, while the trade union figures show employment in the engineering industry to have been exceptionally good in the twelve months to October, 1920, the result, so far as exports are concerned, has been, in a productive sense, deplorably poor. The figures on which this diagram is based are given in Table II, on page 881.

Before leaving this diagram I wish to direct your attention to an addition I have made to it. It shows a state of affairs of which no one in our engineering industry, either employers or trade unions, can possibly regard as other than deplorable, highly dangerous, and extremely significant. The figure given is that of imports of automobiles of all classes, and I have added to the figure the import duty assessed on an overall basis of 20 per cent., on account of the commercial vehicle part of the total not being subject to duty. Accordingly, the figure represents the payment made by British citizens to the outer world and to the Treasury for a single class of engineering commodity, and discloses the failure of the British manufacturer and his workmen to supply what is in the main a utility commodity. It is, in fact, a huge potential industry which we can only hope is merely temporarily lost. It represents a loss of employment to many thousands of British workpeople, and it has been brought about in the main by lack of imagination on the part of our industrialists and by the most deplorably bad guidance of the workpeople of this country by the British trade unions—in particular, the Iron Moulders' Union.

While we suffer from the loss of a census of production to enable us to gauge our real total productivity, we can form an approximate idea from the figures of tonnage carried by the British railways in 1913 and in 1920, and these are as follows :—

	Tons.
1913	366,700,810
1920 (at the rate of first six months)...	330,000,000

They show a fall in activity of approximately 10 per cent., but are subject to a variety of qualifications, and there appears to be a somewhat general consensus of opinion that an accurate estimate would be that in the twelve months ending October, 1920, we produced 80 per cent. of what we did in 1913. It is a reasonable conclusion to draw that to reach these figures within two years after a great war is a remarkable performance ; but it is equally reasonable to conclude that, our present standard of living being obviously higher than that of 1913, we are continuing to live on our capital or on mortgages of our credit.

Having dealt with the more general aspect of the situation through these diagrams, let me now give you certain examples of the everyday class of difficulty which stands in the way of confidence, progress and recovery. Publicists and politicians, economists, and many of those who speak in the name of labour, are inclined to deal with the more philosophical side of to-day's situation ; but it is necessary to remember that in industry the material aspects of an order book, a cost analysis and a balance sheet are the bases of industry, and the provision of the necessary number of thousands of pounds in cash to pay the wages of a large establishment every Saturday morning without fail may be a wholly material consideration, yet it still remains the main factor and consideration in the welfare of our people.

Fig. 5 shows the coal situation in terms of tonnage output, wages cost per ton and production per operative engaged, and the considerations involved in this diagram lie at the very root of our difficulties and of any possible recovery and improvement in our general industrial situation. The most direct influence of high coal costs is reflected, of course, in the cost of production of iron and steel, and of industrial power, light and transport.

Let me now take the case of, say, a British manufacturer of gas engines, in which a large part of the total cost of production lies in the cost of foundry iron, and assume that this manufacturer's main competitor is in America, and they are both tendering to a possible customer in India. The following are the prices a fortnight ago of foundry iron delivered in Glasgow, and including the influence of exchange rates :—

Scottish Foundry iron ...	13*l.* 16*s.* per ton.
American foundry iron ...	15*l.* 10*s.* per ton.
Belgian foundry iron ...	11*l.* per ton.

Eliminating the exchange influence, and deducting freightage, it is obvious that the American gas engine builder is paying 8*l.* 19*s.* 2*d.* per ton for his raw material, or 35 per cent. less than the British manufacturer. No degree of technical superiority or quality of workmanship can continue for long to overcome such an overwhelming handicap of cost.

Fig. 4. ANALYSIS OF ENGINEERING EXPORTS FOR 12 MONTHS ENDED OCT. 1920.

Blank Portion of 1920 Columns Indicate Values Reduced by 66⅔ Rd.

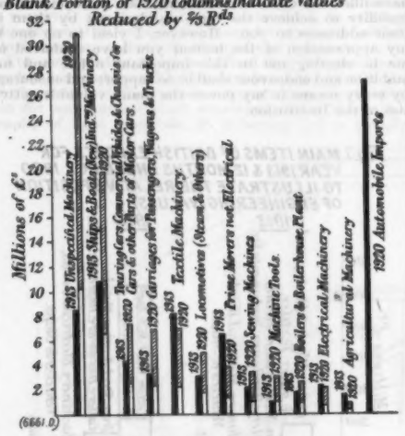
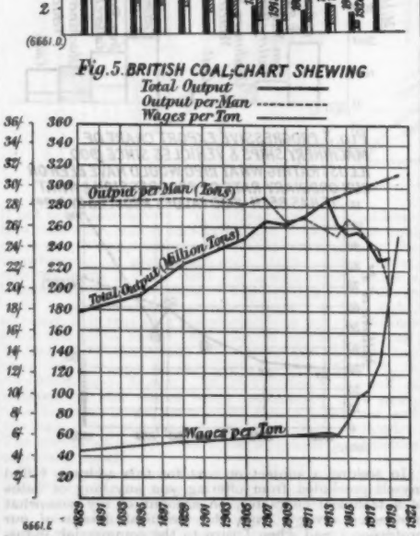


Fig. 5. BRITISH COAL CHART SHEWING

Total Output ——
Output per Man ----------
Wages per Ton ——



Another example of last week's prices might be quoted :—

Bar iron delivered Glasgow—

Scottish makers	27*l.* 10*s.* per ton.
American makers	25*l.* per ton.
Belgian makers	14*l.* 10*s.* per ton.

Proceeding now a stage further to the finished machine, I will take as an example the results of an inquiry recently sent out for a large multi-spindle milling machine to three makers of equally high repute in England, America and Germany. Their proposals were all practically equal in technical merit, and, allowing for freight and exchange, the following were the comparative prices and deliveries :—

Maker.	Price.	Delivery.
English	4,870*l.*	... 8 months.
American	4,800*l.*	... 4 months.
German	3,060*l.*	... 9 months.

From this it is obvious that, making the necessary deduction for exchange and freight, the American manufacturer could instal this milling machine in his American works for the sum of about 3,300*l.*, securing thereby a very considerable capital saving over his British competitor.

Last week a well-known Scottish firm placed a contract for 1,200 tons of iron castings in Belgium at 28 per cent. below British prices, and with guaranteed deliveries, which no British foundry could give them. It is also the case that new foundries are actually being built in Belgium and Holland to produce iron castings for the British engineering industry. To-day locomotive parts are coming from America to this country in spite of the exchange. More ridiculous still, it is reported that bricks are being imported from Norway and cement from Belgium.

To complete this picture of actual and definite examples of governing conditions, let me indicate the conditions in another sphere of industry which is vital to our industrial system. I refer to the great general service of industries—the railways of this country. In his evidence given before the Committee on Railway Rates, Mr. Donald Matheson, the General Manager of the Caledonian Railway Company, submitted the following figures :—

Salaries and wages—

1913	4,200,000*l.*
1920	17,250,000*l.*

representing an increase in wage cost of 310 per cent.

Number of employees—

1913	64,620
1920	83,320

Increase in number of employees of 29 per cent.

I do not think it is submitted by anyone that British railways are doing substantially more work to-day than they did in 1913. Accordingly, assuming that they are doing the same work, then that work is taking 29 per cent. more people and costing 310 per cent. more money. A further extract from the evidence given before the Rates Committee by Mr. Watson, of the North British Railway Company, disclosed that in 1913, at a small country railway station, they had one signalman at 23*s.* per week. To-day they have two signalmen at 70*s.* per week. These men have to deal with two trains each way per day. The increased cost of dealing with these four trains to-day is roughly 600 per cent. While this is perhaps an extreme case, other figures show the wage cost of operating a railway station now is at least three and a-half times the cost in 1913.

It may be of value to quote another example in regard to the financial handicaps. Let us assume that in 1913 a business required the sum of 100,000*l.* to carry its stock, work in progress and to meet its everyday working expenses. The interest charge on this at 5 per cent. would represent the annual sum of 5,000*l.* To-day the capital sum required would be not less than 300,000*l.*, with an interest charge of 8 per cent., or 24,000*l.*, but in addition to this, owing to the disorganisation of industry and of general services, together with the fall in productive efficiency, the period required to secure an equivalent turnover of goods will be not less than 25 per cent. greater than in the past. This would involve an extra interest charge of 6,000*l.*, and thus indicate a total interest charge of 30,000*l.* in 1920, as against 5,000*l.* in 1913.

Another example which might be quoted has connection with the production of houses. This example concerns every tax and ratepayer in the country, and serves to show very clearly certain aspects of industrial and political inefficiency. The problem of housing was, broadly, a simple one : an urgent demand on an abnormal scale for the provision of a specific product—houses. Assuming that material would be forthcoming, and would not represent a limitation, it is obvious that the rate of production of the houses would be determined by the amount of available labour and the efficiency of that labour. It was equally clear that, as the demand was abnormal, there would be an immediate limitation caused by lack of labour, and that failure to achieve the desired rate of completion of houses was certain unless new labour could be trained and utilised and new methods devised to enable unskilled labour to be used. That course has not been adopted, and the rate of completion of the houses, or, rather, the production of houses, represents the most spectacular productive failure in history. While failure in production is a very serious matter, even more serious is the inefficiency of production which is represented by excessive cost. May I put it that the conditions of work in the building trades are now such that it is no exaggeration to suggest a fall since 1913 of 33 per cent. in the overall man-hour efficiency of performance ? Under normal conditions of private enterprise inefficiency sooner or later brought about bankruptcy, cessation of demand and unemployment, but to-day's conditions, wherein the housing situation is almost entirely a State or local authority enterprise, no insolvency-compelling balance sheet has to be faced. Consequently, housing proceeds under conditions of dangerously low efficiency—an inefficiency subsidised and paid for by the taxpayer.

If we are to take these examples and phenomena as typical of the situation, then certain general conclusions must be drawn and remedial means must be suggested. I do not suggest means taken merely by employers of labour, but rather those to be taken by industrial authorities as a whole, comprising employers, trade unions and the Government. No policy or course of action peculiar to any one section, such as engineering, is sufficient, on account of the interconnection and interdependence of industries and services. Coal, for example, has a dominating influence over practically all our industries. Furthermore, it is clear that no single step and no single factor of policy, and, above all, no immediate or revolutionary change, can be effective. We must first recognise that our population can only hope to support itself on a decent standard of living by operating as an almost purely industrial community working under conditions of extreme efficiency, conditions involving a high perfection of organisation, a higher standard of technical progress, coupled with complete unity of effort on the part of the associated authorities. Naturally, such conditions necessarily comprise economy and efficiency in the conduct of our administrative system of government and its policy. We must also

recognise the brutal fact that our present standard of life must inevitably fall from its present level until the disorganised portions of the world are again in a position to produce and interchange goods with us, and enable us to produce and sell not only on a quantitative scale at least as great in proportion to our population, as in 1913, but on equally efficient terms. Our existing standard of living can only be maintained by a quantitative production per head greatly in excess of that in 1913 and under a state of man-hour efficiency at least equal to that of 1913. Let it be quite clearly understood that we are now faced with the definite problem outlined and forecast by Mr. Lanchester and others, and that, having successfully achieved victory in war, we are now confronted with the problem of supporting ourselves in peace. We are now a poor nation, requiring to interchange goods and to compete with nations both richer than ourselves and poorer than ourselves. For example, if the German steel worker or coal miner is prepared to rebuild the prosperity of his country by working conscientiously for 10 hours per day at a low remuneration, then we are faced in this country with only three alternatives—first, to do the same as the Germans; second, to find some methods of achieving the same results by greater efficiency of effort; or, lastly, to reduce our population through emigration.

The influence of a depreciated exchange appears at first glance to help Germany in her exports rather than otherwise, but from the British point of view the most serious influence is the handicap it lays on Germany's power of purchasing from us. I am one of those who believe that we should do our utmost to help the ex-enemy nations and other unfortunate communities of the world within the limits of our slender means—for example, by giving whatever small credit we can still afford to allot to them; but the most fruitful, helpful influence for everyone can only come from the results of our own increased domestic efficiency and economy. I trust that no artificial measures may be taken to build up trade barriers of any kind in this country. The requirements of modern warfare are such that practically no country can be said to be self-contained for a long defence; and if this is accepted, then it must be recognised that in Britain the only industry which might be termed a real key industry is agriculture, and, as we obviously cannot render ourselves independent in regard to food, the entire key industry argument fails. Furthermore, it is hoped that financiers and bankers may not devise and set in force any experimental measures in regard to currency or credit adjustment which may tend temporarily to prevent the full play of the real economic elements. By no method of international financial juggling is it possible to withstand permanently the ultimate influence of national man-hour efficiency of production.

The usual manifestation of industrial depression is, of course, unemployment, and we are all indebted to Mr. J. H. Clynes for his courage in stating last week that "from one cause or another this year of 1920 has been one of low production, and it is towards the end of this year of low production that we witness the highest figure of unemployment which workmen have had to face in recent years. If it were true that low production found work for others, that would have solved the unemployment problem and have absorbed those hundreds of thousands of men." We are merely reaping to-day the character of crop sown in the last two years. Accordingly, it is perfectly natural that to-day we find the closest attention being given by the Government, local authorities and trade unions to measures for dealing with unemployment. In the main, these proposals concern the extension of out-of-work benefit and of provision of relief work, such as arterial road-making. For example, only recently a deputation from the National Alliance of Employers and Employed urged upon the Government action of four classes:—

1. To make less onerous the conditions under which out-of-work benefit is to be paid.

2. To encourage workmen and employers to come together to divide out the available amount of work.

3. To constitute district councils to co-operate with local authorities on the provision of relief work.

The fourth proposal is the one to which attention should be directed. It reads:—

4. To make special arrangements for the supply of available unemployed labour to schemes for contracts, whether under the control of the Government, municipalities or private persons, which are of sound economic nature, where such schemes or contracts are held up for want of labour, and that union rates of wages be guaranteed in all such cases.

Such a proposal implies that there exists to-day contracts and schemes of a sound economic nature which are being held up for want of labour at a time when hundreds of thousands of men are out of work—a time, moreover, when unemployment threatens to become one of the gravest national questions we have ever had to face. This paradoxical situation actually exists. Now, what are the special arrangements referred to? In effect they are to involve appeals by the community to certain sections of the community—the trade unions—to allow unemployed men to be employed on work which is actually available, and on which these men are urgently required, to provide housing. For over twelve months the Ministry of Labour has negotiated with the building trades to allow a measure of freedom of employment. The results up to now, in a practical sense, are nil, and we all appear content to witness the phenomena of vast unemployment and an acute shortage of labour. An exactly similar state of affairs exists in the iron foundry industry. It is a curious paradox that our Press, which has been so indefatigable during the past few weeks in pressing for the saving of a very small number of millions by economy in the personnel of Government offices, should have devoted its attention to a waste campaign on a factor so relatively insignificant and entirely failed to point out the greatest waste which has ever existed in this country—the deliberate restriction of employment of the people through the action of practically a few individuals controlling a section of the people. The rendering immobile and unemployable of a large portion of our population is a waste of human capacity of the most flagrant kind, and the responsibility for this lies primarily at the door of certain of the craft unions. Incidentally, these examples of the action of representative trades unions afford a singularly illuminating light on the plea of the advanced Socialist that community service rather than competitive effort should be the motive of industry. A motive which is incapable of asserting itself under circumstances so vital to the well-being of the nation, and which is so overlaid with what can scarcely be distinguished from an arrogant selfishness, is scarcely a motive on which to rely for the foundation of a new structure of industrial society.

When the serious situation evidenced by the examples I have given is considered, it must be obvious that the present position could not have arisen from any ordered progressive economic system, but must necessarily have been the outcome of pressure of moral forces. We cannot have brought ourselves so close to industrial suicide unless under some strong compelling influence exercised regardless of material consequences. This is true; and the influence in question has been the utilisation of the political power of the trades unions by advanced Socialists to bring about the overthrow of private capitalistic enterprise by a process of undermining it, and thereby rendering it unworkable and a failure—and their success is measured by to-day's situation. War time conditions, together with the social dangers incidental to a demobilisation and re-settlement period, have enabled this pressure to be exercised on industry, and thereby produced the conditions under which industry is operating to-day. We are now witnessing the preliminary results of the manifestation of political power of the trades unions on our social and industrial system, and it is to be noted with care that this power is being exercised without any direct responsibility.

We are now, as a matter of actual fact, well advanced in a system of "unstable semi-Socialism," such as Sir Henry Wrixon outlined with unerring foresight in "The Pattern Nation," published in 1906. Therein he says: "It is surprising how easily and almost imperceptibly measures are adopted and principles conceded which, when worked out to their natural effect, would sweep away the very system of industry altogether. A few simple laws, distributing wealth and altering the conditions of employment, would, in a generation or so, render our present system of life and industry a thing of the past. Under the conditions of semi-Socialism the leaders seek to combine the comfort of Socialism without its discipline with the freedom of individualism without its spur—competition. They glory in the beneficence of the Socialistic state, but do not face its responsibilities, and denounce the tyrannical capitalistic system while they live in the fruits of its industry."

To-night I do not attempt to suggest how this situation and its tendency should be counteracted in any political sense. I confine myself to the demonstration of its incidence and a recognition of it. In the normal course, it will become a definite political issue, and let us hope, will be subjected to the searchlight of continuous and practical examination on the part of workman electors. Meanwhile, it is of value to find Mr. Clynes, one of the most thoughtful Labour leaders, confessing his belief that we must accept the present system and structure of society, improve it, and work it to yield the best results to all associated with it. On the other side we have Mr. G. D. H. Cole, of the G.H.Q. of Labour, stating at the Coal Industry Commission that he is convinced there is such a feeling of antagonism between employers and employed that any complete or efficient system of co-operation is now impossible. He believes the difficulty will increase and not decrease, and that the unrest in industry is founded on the worker's feeling that his position under the capitalist system is an unjust position. If that were true, there would be real grounds for pessimism on the part of all, but it is not the case that the relations which are bad are the relations in the workshops between the workers and the management. In the shops the human influence exists perhaps healthier and stronger than ever, but this influence is to-day imprisoned and without opportunity to expand and do its valuable work. The controlling influence is not that directed by the workmen, but the influence directed and imposed by to-day's trade-union policy, which is towards regimentation of the men and hostility to true co-operation. The doctrinaires who frame the alleged aspirations of the worker, and give form to his hypothetical claims, are as far removed from realities as the

TABLE I.—EXPORTS 1913 AND 1920.

	1913.		12 Months ended October, 1920.	
	Value. £	Tonnage.	Value. £	Tonnage.
1. Coal	53,658,636	76,687,241	105,008,003	27,609,960
2. Iron and steel and manufactures thereof	54,328,292	4,935,203	121,040,465	3,255,884
Other metals and manufactures thereof	13,288,350	—	26,311,895	—
Cutlery	7,974,457	—	12,822,298	—
Totals	75,000,000	4,935,203	160,000,000	3,255,884
3. Electrical goods	5,404,671	—	10,395,963	—
Machinery	37,027,582	746,778	56,145,447	426,248
Vehicles—				
(a) Railway carriages, motor cars, &c.	11,373,536	—	30,454,952	—
(b) Ships	11,031,236	484,139	19,948,188	357,796
Totals	64,000,000	1,230,000	116,000,000	783,000
4. Cotton yarns	127,206,820		393,699,922	
Woollen and worsted	37,686,781		136,864,788	
Silk and silk manufactures	2,157,013		5,256,173	
Other textiles	14,826,432		43,618,356	
Apparel	16,426,112		45,258,892	
Totals	198,000,000		624,000,000	

TABLE II.—ANALYSIS OF ENGINEERING EXPORTS FOR TWELVE MONTHS ENDED OCTOBER, 1920, AND FOR THE YEAR 1913.

	1920.		1913.	
	Value. £	Tonnage.	Value. £	Tonnage.
Locomotive (steam and other)	5,100,000	30,000	3,300,000	56,000
Carriages for passengers and wagons trucks	7,100,000	—	3,300,000	—
Touring cars, commercial vehicles and chassis for motor cars and other parts of motor cars	7,500,000	—	4,301,000	—
Ships and boats (new) including machinery	19,948,188	357,796	11,031,236	484,139
Agricultural machinery	950,000	10,200	1,637,873	43,180
Boilers and boiler house plant	2,700,000	37,000	1,777,740	68,612
Electrical machinery	2,200,000	10,600	2,275,442	27,049
Machine tools	3,100,000	22,300	1,009,180	16,556
Prime movers—not electrical	3,930,000	31,000	6,600,000	125,000
Sewing machines	3,400,000	22,000	2,158,206	30,686
Textile machinery	7,100,000	53,000	6,281,937	178,097
Other machines and machinery	31,000,000	221,000	8,640,684	172,260

IMPORTS, 1913–1920.

	Twelve Months ended October, 1920.	1913.
	Sterling	Sterling.
Motor cars, chassis and parts thereof	£22,850,428	£7,411,258

TABLE III.—EXPORTS 1900–1920.

—	1900.	1905.	1910.	1913.	1914.	1915.	1919.	Twelve Months to October, 1920.
	£	£	£	£	£	£	£	£
Machinery	19,619,784	23,260,326	29,271,380	37,012,635	31,363,093	19,164,537	32,670,013	56,145,447
Ships	8,500,000	5,431,298	8,770,204	11,026,530	6,932,554	1,692,661	2,328,331	50,420,000
Vehicles	2,500,000	4,000,000	7,449,977	11,365,888	11,229,558	6,578,013	13,827,003	
Totals	30,600,000	32,600,000	45,300,000	59,300,000	49,400,000	27,200,000	48,700,000	106,500,000

worker himself is from the true inwardness of their philosophy. The direction of the trades unions proceeds not from below, but from the careerists and word-spinners who dominate their councils and utilise their positions for furthering their own particular brand of world re-building.

Meanwhile, the greatest good can only come from the concentration of thought and action on dealing with the realities of our present situation and the exercise of sincerity and frankness in determining the action to be taken. The industrial policy of the present Government, and of its two predecessors, has sensibly contributed to bring about the present instability in our industrial affairs, and the consequent inefficiency of our industrial production, and it is now clear that any really progressive policy should be to provide a definite constructive programme based on the maintenance and encouragement of private enterprise, which will detach the moderate and saner-minded elements in the trade union movement, and in the working community, from following Labour leaders intent on the supersession of the industrial and social order. As the betterment in conditions, status and standard of living rest primarily on the definite results and productive resources of our industry, and as the State has now definitely assumed responsibility for guiding, and in a measure controlling, industry conditions, it is for the Government to demonstrate that the proper functioning of the community as a whole for industrial production can be best achieved in a particular way, and by the removal of certain disabilities rather than in another way by the maintenance and increase of these disabilities. Such a programme would be the best corrective to revolutionary propaganda, and, moreover, can be consistently combined with the encouragement and extension of real trade unionism along legitimate lines of useful and productive development.

The improved working conditions which have now been arranged with the leading engineering unions, providing for shortened hours, better terms of payment for nightshift and overtime, should be recognised as the limit to which economic production can possibly go under existing handicaps, if, in fact, this limit is not already overstepped. It is therefore necessary for all associated with industry—employers and workpeople—to realise that nothing further must be done at the present juncture which will in any degree bring about an increase in the cost of production. On the other hand, every reasonable and justifiable step should be taken to reduce cost. Stability and confidence are the vital requisites in any campaign of improvement. Fixed prices, firm contracts and guaranteed deliveries are the elements in restoring confidence. But no one partner in industry is capable of infusing into it a new spirit; the writing on the wall must carry conviction to all parties, and the trades unions must respond as well as the employer, and justify their protestations of good faith and their sincerity for helpful co-operation. A touchstone of their earnestness might be found in their willingness to agree to stabilisation of wages for a period, in order that industry might have a breathing-space free from wage disturbance, and in their withdrawal of the veto on the introduction of sound systems of payment by results. The recognition by, say, the building trade union and by the ironmoulders' union of the folly of paying unemployment doles and creating relief work, at a time when their industries were never in a better position to absorb and utilise the services of the unemployed, would be a contribution to our national problem at once helpful in itself and valuable as an evidence of the will to assist. If the Miners' Federation were to translate their knowledge that the high cost of coal is the biggest single factor in the high cost of iron, steel, and our services of transport, light and power into a programme of conditions for the negotiations now pending, under which the price of coal could be reduced, and the quantity available for export go up, there would be created a new atmosphere and spirit which could not fail to react for good on the whole industrial situation.

Concurrently with these manifestations of a true regard for the national industrial welfare on the one side, it is incumbent on the employers and the State to undertake to the limit of their possibilities the obligation of genuine unemployment relief. In view of the Government having already undertaken a substantial portion of this, it should be obvious that a duty is imposed on them of seeing that no artificial restriction of employment takes place, and that obstacles to industrial freedom over which they can exercise control are dealt with in the interest of the nation as a whole, and not for the preservation of a sectional privilege.

It is impossible in an address such as this to do more than deal with a few aspects of the complex system of industry, by which we live, but it can be claimed with some conviction that, whatever evils and inequalities exist in our British system, it is one which stands to-day as the best solution of the world-wide problem yet evolved. It is a system which has been liberalised and humanised by the growth of a healthy and critical public opinion—a system which is continuously being improved and adapted to our conceptions of social evolution, and which offers a more certain path of development to the human race than any form of Socialism, vitiated as every such form is by the neglect of that simple consideration—the experience of ages in human nature.

Hydro-Electric Developments in North America.—Surveys now in progress in the United States contemplate the transmission of power from the St. Lawrence to New York, Philadelphia and Washington, according to *The Canadian Engineer*, Toronto.

SOME FEATURES IN THE BEHAVIOUR OF BETA BRASS WHEN COLD-ROLLED.*

By F. Johnson, M.Sc., Member (Birmingham).

In the course of a recent investigation the author came across an interesting case of the behaviour of beta brass when cold-rolled. The alloy in question was made from electrolytic copper and electrolytic zinc, and had the following composition —

	Per cent.
Copper	55·6
Zinc	44·4
Iron and lead	traces.

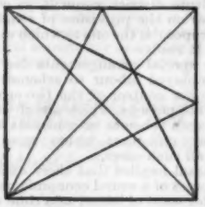


Fig. 1. Intersections of Cube Face by (211) Planes.

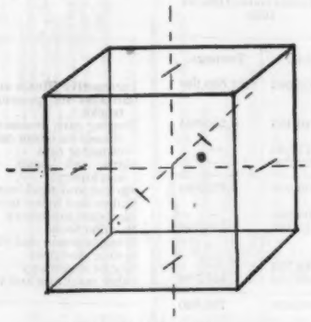


Fig. 3. Cube (001).

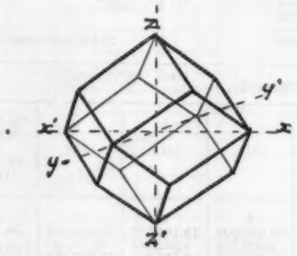


Fig. 5. Rhombic Dodecahedron (011).

It was in the form of a chill-cast ingot 0·75 in. square, the sides having been planed smooth, leaving the bar 0·72 in. square. The pouring temperature of the alloy was 1050 deg. C., the temperature of the cast-iron mould was 112 deg. C., and the walls of the latter 1 in. thick. A feeding-head of metal was arranged for the whole length of the ingot, which was cast horizontally. This ingot was annealed at 650 deg. C. for one hour and slowly cooled. It was then cold-rolled without further annealing in a number of passes to a thickness of 0·365 in., thus having undergone a reduction of 50 per cent. The test results obtained on the ingot before and after annealing and after rolling are given in Tables I and II.

The edges of the rolled strips were showing marked signs of distress when the rolling operation was stopped, several incipient fissures having appeared. It will be seen from Table I that a marked increase in tenacity and a very serious decrease in percentage elongation have resulted from the cold-working. It was a new experience for the author to find that an alloy consisting entirely of the beta phase was amenable to such severe deformation. Photomicrograph Fig. 7, opposite, shows that none of the alpha phase existed, the alloy being in a metastable condition.

The microstructure of the rolled alloy proved to be of so interesting a character as to suggest to the author the desirability for publication. In view of the unexpectedly great amount of plastic deformation which the alloy had undergone there appeared to be much promise of an interesting record of its behaviour being found in the microstructure. When first polished and etched, the microstructure of the rolled alloy revealed little more than the elongation of the large crystal grains, but when very carefully polished and etched for one minute in a 10 per cent. solution of ammonium persulphate, a confused maze of dark lines was revealed, the lines being at first mistaken for scratches, particularly as beta brass is a most difficult alloy from which to eliminate scratches. There were still a few scratches on the specimen, but on closer inspection it was found that by far the greater number of the dark lines were straight and formed in series, in each of which they were parallel to one another, the series crossing each other at various angles. After regrinding and repolishing the surface with still greater care, and etching in the same way as before, the dark lines were again revealed with striking clearness and intermingled with fewer scratches. Several photomicrographs were taken (Figs. 8 to 12, opposite,

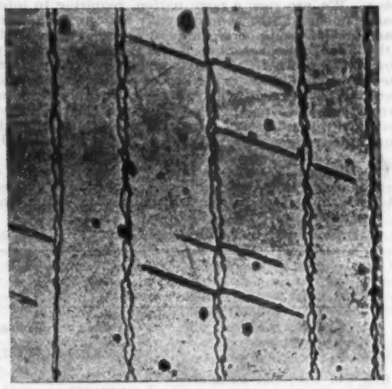


Fig. 2.

Fig. 4. Octahedron (111).

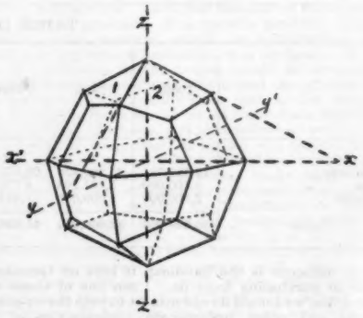


Fig. 6. Trapezohedron, Leucite (211).

Table I.

Mark and Description.	Treatment.	Yield Point. Tons per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation per cent. $l = 4\sqrt{\text{Area}}$.	Hardness. Brinell 500 Kilos.	Hardness. Shore (Magnifier Hammer).
5A. First melt, copper, 55·6 per cent.; pouring temperature, 1050 deg. C.	As cast ..	7·7	25·5	17	95	23
	Annealed ..	6·9	22·67	27	86	21
	Cold rolled, 50 per cent. reduction	..	38·2	8·6	173	55
	Cold rolled, 50 per cent. reduction. Annealed 400 deg. C., 60 min.	..	27·65	21·2	93	20
5AR. Second melt, copper, 55·4 per cent.; pouring temperature, 900 deg. C.	As cast ..	8·5	29·3	22	95·5	23
	Annealed ..	7·6	29·4	28	86	20
	Cold rolled, 50 per cent. reduction	36·3	41·1	4·25	173	55

* Paper read before the Institute of Metals, at Barrow-in-Furness, on September 16.

and page 884). A marked feature of the lines, and one which proved that they represented planes of slip, was the manner in which individual lines were stepped, owing, of course, to the fact that a displacement of crystalline layers in one direction (indicated by one series of parallel lines) was succeeded by a displacement of crystalline layers in another direction. It was found that the slipping of layers across displaced layers ("faulting") in this way had caused severe displacement at the crystalline boundaries, as shown in Fig. 11 (page 884) where an originally continuous boundary is shown strongly serrated. The straightness and etching be-

FIG. 7. Ingot as cast and annealed. ×35.

FIG. 8. Cold-rolled (50% reduction). ×100

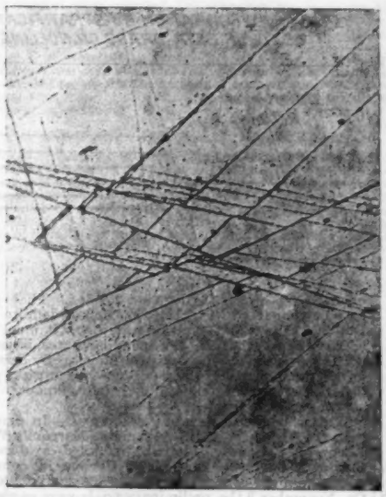


FIG. 9. Same as Fig. 8.

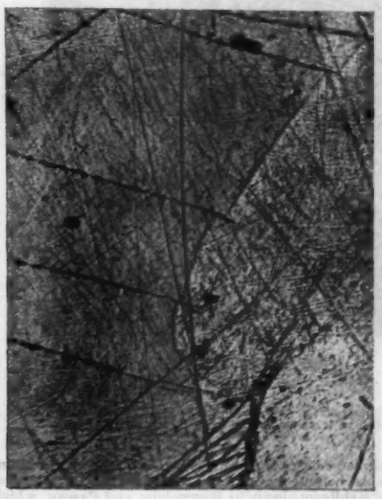


FIG. 10. Same as Fig. 8.
Shows displacement at crystal boundary.

Etching treatment for all micrographs (Figs. 7-14) was by simple immersion in ammonium persulphate (10% solution) for one minute.

haviour of these lines were such as to suggest the possibility of their correspondence to the Neumann lamellæ found in meteorites and in ferrite which has been subjected to shock. Ample reference to these lamellæ is made by Osmond and Cartaud,* and by Howe.† Osmond and Cartaud refer to them as follows:

"The lamellæ known as Neumann's lamellæ . . . in honour of the savant who discovered them in 1850, have been recognised for a long time in cubical meteoric iron and in Kamacite (nickel ferrite). Their presence in terrestrial iron was noted by Prestel. Neumann's lamellæ are visible frequently to the naked eye on a cleavage face. On these faces they are parallel either to the diagonals of the square or to the lines which join the angles to the centre of the opposed edges." (See Fig. 1.)

Some of the properties of these lamellæ are: (1) They are clearly revealed after repolishing and re-etching; (2) They have a very slight but unmistakable thickness, and on this account are supposed by Osmond and Cartaud to be mechanical twin crystals. They may be either uniform in thickness or "nodal" (see Fig. 2); (3) They are parallel to the faces of the trapezohedron (211), and possibly to those of the cube also; (4) They are capable of exhibiting curvature after deformation; (5) They may be effaced from ferrite by heating to above Ac3; (6) They are of a higher order of magnitude and usually straighter than slip-bands, and differ (7) from the latter in their ability to reappear after repolishing and re-etching.

TABLE II.—*Variation of Hardness with Annealing Temperature.*

Mark.	Temperature of Anneal.	Time of Anneal.	Hardness. Brinell. 500 Ks.	Brinell. 1000 Ks.	Shore (Magnifier Hammer).
5A	As rolled ..	..	173	192	55
	250 deg. C.	30 min.	100	129	24
	300 deg. C.	30 min.	100	129	23
	400 deg. C.	30 min.	93	..	20

In ferrite Linck found the angles 114° 6′ and 144° 44′ between the surfaces of Neumann strata and the faces of the containing cube, and 131° 49′ between the surfaces of the Neumann strata themselves. In the case of a cube each of the three axes is intercepted by two of the six faces at a common distance from the centre. If that distance be taken as unity, then the ratio between the intercepts of the cube faces on the axes is ∞ : ∞ : 1, since each face runs parallel to two of the axes and may be said to cut them at infinity (see Fig. 3). The Miller indices are the ratios of the reciprocals of these intercepts, and in the case of a cube are 0 : 0 : 1, which conveniently expressed is 001. In the case of the octahedron the ratio is 1 : 1 : 1, since each face cuts three axes at unit distance. Its index is therefore 111 (see Fig. 4). In the case of the rhombic dodecahedron, as will be seen from Fig. 5, there are 12 faces, and each of these is parallel to one of the three axes, but cuts the other two at unit distance. The ratio of the intercepts is ∞ : 1 : 1 and the index 011. In the case of the trapezohedron (leucite) there are 24 faces (see Fig. 6), and each of these cuts one of the three axes at half the distance at which it cuts the other two, which it cuts at unit distance.* The ratio of these intercepts is ½ : 1 : 1, the ratio of their reciprocals 2 : 1 : 1, and the index 211. It is to these trapezohedral planes that the Neumann lamellæ are parallel.

To study the angles at which the Neumann strata cross one another, and compare them with the angles at which the trapezohedral planes cross one another, it is desirable to select if possible a crystalline face corresponding to or parallel to, a definite crystallographic plane, such as the face of a cube or of an octahedron. This has been done in the case of ferrite by, *inter alios*, Osmond, and Cartaud and Howe. In the specimens examined by the author no means were available of isolating any definite crystallographic plane. The intersections of various crystallographic planes of deformation give the following angles:—

161°, between lines G H and K L (see Fig. 15 of photomicrograph 9).
142°, angle D E F (see Fig. 15 of photomicrograph 9).
135°, angle A G H (see Fig. 15 of photomicrograph 9).
117°, angle J C E (see Fig. 15 of photomicrograph 9).
124° and 127°, angles A D C and A B C (see Fig. 16 of photomicrograph 8).

The first of these (161°) corresponds exactly to the angle formed by the intersection of 211 planes on a cube face, and also to the angle of intersection of an octahedral truncation of a cube by 211 planes. The second (142°) approximates to one of the angles (139° 6′) of intersection of an octahedral truncation of a cube by 211 planes. The third (135°) corresponds exactly to one of the angles of intersection of a rhombo-dodecahedral truncation of a cube by octahedral planes. This angle appears to be the predominant one in Fig. 16 (compare Fig. 8). The fourth (117°) approximates to the angle (116° 34′) of intersection of a cube face and 211 planes.

It will be seen that in three of the four angles measured the trapezohedral (211) plane appears to constitute one of the planes forming the angle, but it is necessary to point out that the crystal face under examination is one taken at random and may not necessarily be parallel to a cube face or to an octahedral truncation of a cube.

In photomicrograph Fig. 12, page 884, another phenomenon is to be seen. Broader bands of different etching tint from that of the main body of the crystal run parallel to one another, and are intersected and faulted by some of the fine dark lines which, as above indicated, are believed to be Neumann lamellæ. These bands are discontinuous and exhibit no uniformity of thickness. If they were strata intersecting the Neumann lamellæ at an acute angle, there appears to be no reason why they should not exhibit continuity. They are far too numerous to be acicular crystals of the alpha phase, and are of quite local occurrence.

Although the phenomena above described are to be found in a cold-worked unannealed specimen, the specimen from which the photomicrographs were prepared had been annealed at 250 deg. C. for thirty minutes This treatment appeared to bring the lamellæ into greater prominence for the purposes of photomicrography.

In Fig. 11, page 884, it will be noticed that the parallel lamellæ are nodal in character, and it was thought that this peculiarity was due, not to the cause which Osmond and Cartaud adduced to explain its appearance in the Neumann lamellæ of ferrite (see Fig. 2), but to the incipient deposition of the alpha phase along the Neumann planes. In order to throw further light on the matter specimens annealed at 350 deg. C. and higher temperatures were examined, and it was found that the alpha phase had crystallised along the Neumann planes in a strikingly beautiful way, thus confirming the author's earlier hypothesis (see Figs. 13 and 14).

These annealed specimens present markedly similar features to those possessed by a martensitic structure. Osmond and Cartaud suggested that in such a structure the α-iron was retained pseudomorphic on the martensitic structure of γ-iron, the treatment of the metal having prevented the reconstitution of equiaxial grains characteristic of α-iron. They stated that the grains of α-iron were cut up by an infinite number of extremely thin lamellæ parallel to four different planes, that the continuity of the cleavages (001) was broken, and the natural fragility conferred by these cleavages on α-iron evaded. To this cause they attributed the amelioration of mild steels by quenching and tempering. By annealing a specimen of the rolled bar for thirty minutes well within the beta phase region of stability (685 deg. C.) this martensitic pattern of the alpha phase, crystallised along crystallographic planes of displacement, was effaced, as also were the Neumann lamellæ. The structure reverted to that of the cast alloy (see Fig. 7). One other feature of the effect of deformation on beta brass is perhaps worthy of note. When the rolled strip was sawn either longitudinally or transversely, it was noted that a curious stratification had been developed by the rolling operation. The section was stratified into five layers of approximately equal thickness, these layers

* Journal of the Iron and Steel Institute, 1906, vol. lxxi page 444.
† "Metallography of Cast Iron and Steel," page 415.

* This may be seen from a glance at face 2, Fig. 6, when prolonged to cut axes y y′ and z′z, cuts them at twice the distance from the centre that it cuts axis x x′.

THE BEHAVIOUR OF BETA BRASS WHEN COLD ROLLED.

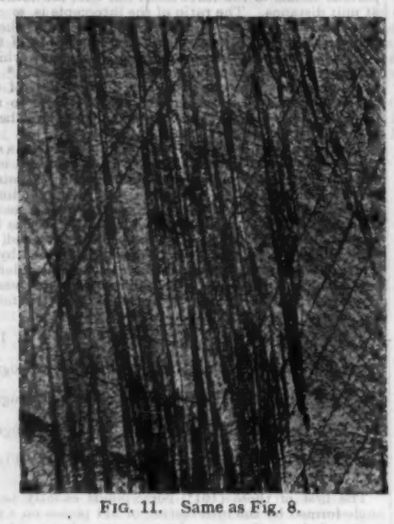


Fig. 11. Same as Fig. 8.

Fig. 12. Same as Fig. 8.

Fig. 13. Cold-rolled (50% reduction) and annealed 400° C. for 30 minutes. ×100.

Fig. 14. Same as Fig. 13.

Etching treatment for all micrographs (Figs. 7–14) was by simple immersion in ammonium persulphate (10% solution) for one minute. In specimens (Figs. 13 and 14), a subsequent polish with magnesia on wet parchment was necessary.

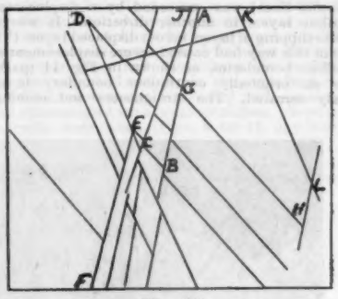


Fig. 15.
(Note 142 deg., angle DEF.)

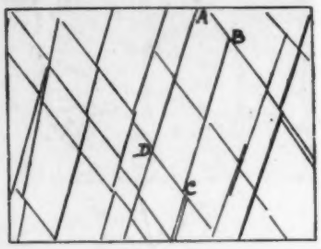
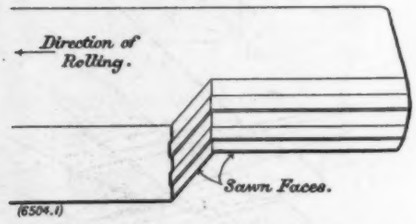


Fig. 16.
(Note 124 deg. and 127 deg., angles ADC and ABC respectively.)

Fig. 17. DEFORMATION BY STRATIFICATION OF BETA BRASS ON ROLLING.



appearing in relief and in recess alternately* (see Fig. 17).

Reference to the list given above of the properties of Neumann lamellæ shows that, with the exception of No. 3, they are all possessed by the lamellæ which the author has found in cold-worked beta brass, and there is distinct promise even of No. 3 becoming attributable to them. The author suggests, therefore, that, failing a more feasible explanation, the conspicuous deformation bands in cold-worked beta brass belong to the same category as the Neumann lamellæ found in meteorites and in ferrite which has been subjected to shock.

The author desires to express his appreciation of the help given by Mr. R. E. Rednall in making some of the tests, and by Mr. G. Bird in the rolling of the ingots.

* Scleroscope hardness measurements were made of each individual layer, but, apart from a general increase of hardness from one rolled face to another (14, 16, 20, 22, 26), no regularity of alternation of hardness was found. Each figure represents the mean of six determinations on each layer.

Rhine-Main-Danube Canal.—The question of a modern canal connection between the Rhine and the Danube became acute again while the war was in progress. A committee which deliberated in February, 1918, at Nuremberg had to deal with no fewer than 23 main schemes and 17 secondary routes. By April, 1919, three main projects had been selected for further examination, and the one of these, finally recommended, follows in part the old Ludwig Canal which had long ceased to satisfy modern requirements. This is in a way intermediate between the other two projects. Common to all the three projects is a regularisation of part of the Main, from Aschaffenburg upward, and also of the Danube, from Kehlheim down to Regensburg and Passau, which lies at the junction of the Danube and Inn, on the frontier of Bavaria and Austria.

The Tarnishing of Metals.—Although the formation and the colours of surface films on metals depend upon the atmospheric impurities, in many cases, in that of the temper colours of steel, the tarnishing is mostly an effect of oxidation. To study the phenomena, however, G. Tammann (*Nachrichten der Gesellschaft der Wissenschaften*, Göttingen, 1919, pages 225 to 236) found it more convenient to experiment with iodine. He placed iodine crystals and sheets of the respective metals under a desiccator. Silver, copper, lead, thallium soon became covered with films which changed their colours as they thickened; on bismuth and antimony a dark dust settled; tin covered itself with an irregular yellow film; zinc and cadmium changed very slowly, chromium not at all; on iron, nickel and cobalt, small coloured spots appeared which, on exposure to the moist atmosphere, became small drops by absorption of water. The increase in thickness of these films depends chiefly on the rate of diffusion of the iodine through the iodide formed; that diffusion is slow, although the chemical reaction itself is rapid. As regards steel, Tammann went back to the experiments of R. Löwenherz, who floated steel foils on fused alloys and metals. Carrying these experiments up to temperatures of 392 deg., Tammann finds that the rate of growth (in thickness) of the surface film is not uniform, and not the same for soft and hard steels. For soft steel the rate is rapid between 204 deg. and 249 deg. C., and again above 350 deg.; for hard steel the rate remains practically unchanged between 325 deg. and 357 deg. These periods may be connected with the formation of definite oxides. But this cannot be definitely stated, and it must also be borne in mind, that the thickness estimates, based upon the interference colours of these films, really correspond to air films showing those colours, the optical properties of the assumed oxide films being unknown.

Wireless Installation at Geneva.—In agreement with the Swiss Federal Government, Marconi's Wireless Telegraph Company, Limited, installed a 6-kw. continuous wave valve station at Geneva in connection with the first conference of the League of Nations. On November 9 the preliminary trials were carried out, and the station was completed and the service commenced on November 15. The transmitting apparatus comprises one Marconi standard 6-kw. continuous wave valve telegraph set of the coupled circuit type, fitted with six "power" and four "rectifying" valves. The power is taken from the Geneva Supply Company and supplied to a 30 brake-horse-power, 500-volt two-phase motor, which drives by belt a 23-kw. 110-volt direct-current dynamo. An emergency power plant is provided, consisting of one 18-kw. 110-volts direct-current Austin oil-engine generator. Each power set is connected to a slate panel switchboard. On 6-kw. motor alternator is installed, taking supply from the 110-volt direct-current giving a single-phase supply at 500 volts 300 cycles. The voltage is raised to 7,500, by a step-up transformer, at which pressure it is fed to the valve transmitter panel. The signalling circuit comprises special high-speed keys operated by a Wheatstone transmitter, the tape for which is "punched" on a Gell keyboard type perforator. The aerial is of the umbrella cage type with six radial members, supported by a single lattice steel self-supporting tower, 200 ft. high, each radial member being carried out to a 50-ft. pole at a distance of 300 ft. from the central tower. Five miles from the transmitting station is a separate receiving station erected so as to permit of duplex working. The receiving station in England is located at Witham, near Chelmsford. For transmitting the necessary acknowledgments, service messages, &c., a 15-kw. valve transmitter at the Marconi Works, Chelmsford, is operated direct from the receiving station at Witham by landline connection.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

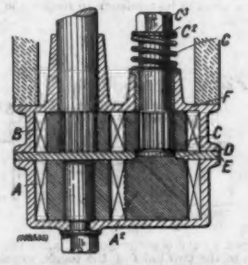
ELECTRICAL APPARATUS.

148,625. The British Thomson-Houston Company, Limited, London, J. Whitcher, Ruislip, and H. W. Taylor, Bilton. Turbo-Alternators. (4 *Figs.*) April 26, 1919.—The invention relates to circuit connections and switching arrangements for the suppression of field of alternating-current generators on the occurrence of a fault on the system supplied by the generator, and also within the generator itself. According to the invention, apparatus for this purpose is provided comprising a

switch adapted when operated first to reduce the excitation of the generator to a low value and thereafter to short-circuit the alternator field circuit. The field winding 1 of the alternator is connected across the terminals of the exciter 2, the field winding 3 of which is connected in series with the loading resistances 4 and 5 and the exciter rheostat 6. These windings are connected as shown to the contacts of a double pole switch, the movable arms 7 and 8 of which are connected to the terminals of the exciter. (*Sealed.*)

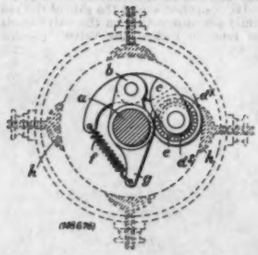
GAS ENGINES, PRODUCERS, HOLDERS, &c.

148,556. Bentley Motors, Limited, London, and F. T. Burgess, London. Oil Pumps. (1 *Fig.*) May 13, 1919.—In a tandem oil pump the spindle is provided with a valve face arranged to make an oil-tight seating against the division plate and means, such as a spring, is provided to ensure the effectiveness of this seating. The scavenging pump A of the gear wheel type is located beneath the pressure pump B, and the driving spindle C of the latter is provided with a valve face. This is constituted by



a curved face D at the junction of the gear wheel A^2 and its spindle C, and this face engages a seating of corresponding shape on the adjacent side of the division plate E separating the pumps A and B. The spindle C is extended at C^2 beyond the pump casing F, and the extension C^2 is surrounded by a spring G which bears against an abutment C^3 on the spindle. The spring G therefore keeps the valve face D seated firmly at all times, and leakage between one pump and the other is prevented. (*Sealed.*)

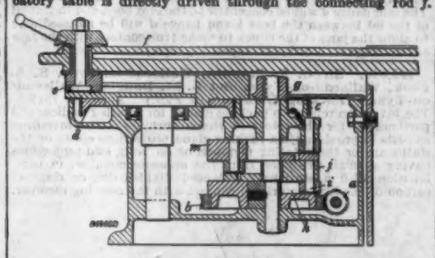
148,676. C. S. Snell, Fakenham. Current Distributors. (2 *Figs.*) June 17, 1919.—The invention relates to electrical commutators or distributors for internal-combustion engines



of the form in which a rotating arm carries a hinged rocker arm having at one end a distributor roller which makes electrical contact with segmental metal contacts let into a circular non-conducting surface against which the distributor roller bears under the action of a spring attached to the tail of the rocker arm. In accordance with the invention, the distributor roller takes the form of a ball or roller bearing comprising an inner and an outer roller separated by balls or rollers. The shaft *a* carries an arm *b* to which is pivoted a rocker *c* carrying at its forward end a roller adapted to roll successively into contact with live contacts *h*. The rear end of the rocker is connected by a spring *f* to the tail *g* carried by the arm *b*. In accordance with the invention, the roller consists of inner and outer portions d^2, d^1, respectively, separated by balls or rollers *e*. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

148,052. Smith and Coventry, Limited, Salford, and I. H. Wright, Salford. Machine Tools for Keyseating. (5 *Figs.*) August 8, 1919.—The invention relates to machines such as are employed for keyseating and like purposes, and wherein a table is reciprocated by a crank disc and slotted cross head or connecting rod. The invention comprises the combination with a driving and a driven wheel, of a transmitting disc interposed between the said wheels and eccentrically mounted and arranged to traverse the reciprocatory element. The driving train includes a worm *a* which engages a worm wheel *b*. The spur wheel *c* engaging a similar wheel *d* forms the driven wheel of the combination and carries the crank disc *e*, from which the reciprocatory table is directly driven through the connecting rod *f*.



The worm wheel *b* is loosely and eccentrically mounted on one end of a fixed shaft *g*, having loosely and concentrically-mounted on its opposite end the spur wheel *c*. The worm wheel *b*, or an extension, has a slot *h* and crank-pin *i* with a disc *j*, freely and concentrically mounted on the vertical shaft *g* and having another driving connection with a second disc *m*, eccentrically and freely mounted on *g*, and which is in driving connection with the spur wheel *c*. The latter wheel is thus rotated by the rotation of the worm wheel *b*, and though both make the same number of revolutions the angular velocity of the spur wheel *c* is varied during each revolution by the relatively eccentric mounting of the transmitting parts or elements and the variations in the radial positions of the driving connections between them. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

148,630. C. F. Priest, Redcar. Muffle Furnaces. (8 *Figs.*) April 26, 1919.—The invention relates to muffle and semi-muffle furnaces. A muffle furnace in accordance with the invention is characterised in that the combustion chamber is adjacent to but not beneath the furnace chamber, and in that the hot gases from the combustion chamber are led first through fire passages in the side walls of the furnace chamber, then across the front of said chamber, then through a fire passage beneath the floor of said chamber, then up a fire passage at the back end thereof, and lastly through a fire passage in the roof of the furnace chamber. In the case of a semi-muffle furnace, a portion of the hot gases is led through the furnace chamber to the back end fire passage. *a* are the combustion chambers which are provided with fire-bars and firing doors and separated by a

Fig. 1.

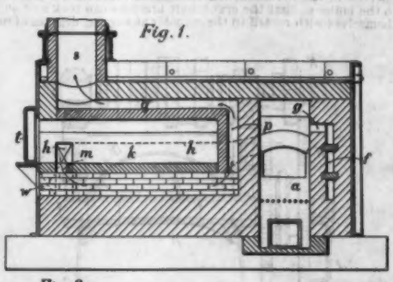
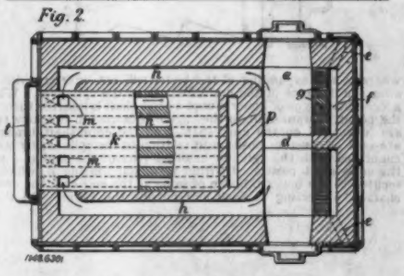


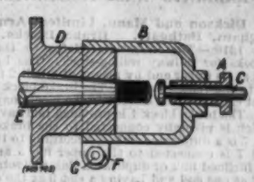
Fig. 2.



bridge *d*. A portion of the air for combustion enters by the lateral air passages *e*, and passes through passages *f* and orifices *g* into the upper portion of the combustion chambers *a*. The hot gases are led from the combustion chambers *a* through fire passages *h* in the side walls of the furnace chamber *k* to the front end of the furnace, where they pass across the front of the furnace chamber, forming a fire curtain, and down through openings *m* into fire passages *n* beneath the floor of the furnace chamber *k*. The passages *n* open into a vertical end flue *p* at the back of the furnace chamber, up through which the hot gases pass to a passage *q* in the roof of the furnace chamber leading to the chimney flue *s*. *t* is the door to the furnace chamber *k*. *w* are loose stoppers which are provided in the fire passages *n* for cleaning purposes. (*Sealed.*)

MOTOR ROAD VEHICLES.

148,705. G. J. Morgan, Merthyr Tydvil, and R. M. Morgan, Merthyr Tydvil. Forcing Wheels off Axles. (1 *Fig.*) September 30, 1919.—The invention relates to a device for forcing wheels off their axles. According to the invention, for the screwed bolt making direct contact with the end of the axle is substituted a machined hollow sleeve A with a hexagon head, the sleeve being screwed to fit the end of the cup B and provided with a turned mushroom or round-headed striker pin C, making an easy fit in the hollow sleeve. The mushroom head of the striker pin C is made of hard steel, phosphor bronze or copper, and is inside the cup between the end of the axle and the inner end of the sleeve, thereby keeping the striker pin from rebounding when struck, whilst the end of the pin projects outside the hexagon head of the sleeve. In using the tool, the hub-cap, axle nut

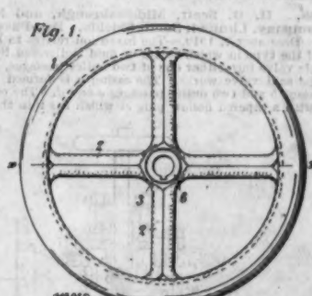


and washer having been removed, the wheel drawer is screwed on the hub D and the sleeve A is then screwed up until the head of the striker C is hard against the end of the axle E. If the wheel still remains fixed, a smart blow of the hammer on the end of the striker will not fail to jar the wheel loose without injuring the screw threads of either hub or tool, or bending the tool. The jarring effect is enhanced by the whole force of the blow being communicated to the axis and wheel, no part of the force being lost by any backward or sidewise movement of the striker C, which is kept forced against the end of the axle E and in exact alignment therewith by the sleeve A. The cup B may be split for part of its length and be provided with lugs F, and bolt or screw G, for clamping to the wheel hub after being screwed on. (*Sealed.*)

148,055. E. Sellman, Wolverhampton, and E. Crosse, Wolverhampton. Steering Wheels. (6 *Figs.*) August 19, 1919.—The invention relates to steering wheels for use with motor vehicles. According to the invention, the rim, boss or boss web, and spokes or connecting web are pressed from a single sheet metal blank, the rim being formed by the metal being turned back upon itself, whereby the rim presents the appearance of a solid member. The steering wheel comprises a rim 1, spokes 2 and boss 3, pressed from a mild steel sheet blank. The rim in this example is oval shaped in cross-section, the meeting edges of the metal lying on the inner side and in the central plane of the rim. These meeting edges of the rim are turned back to form flanges 4, which are superimposed and project inwards of the rim. The spokes pass from the rim to the boss 3, which

Fig. 2.

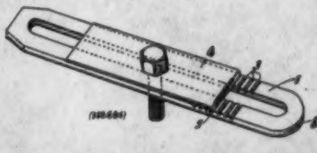
Fig. 1.



latter lies below the plane of the rim, as is usual in this type of wheel. The spokes are oval in cross-section, the sheet metal being curled to meet in the centre on the underside of the spokes, and these turned edges running into said flange on the inner edge of the metal forming the rim. The centre disc of metal, into which the spokes run, is subjected to a pressing operation to form the boss 3. The outer edge of this disc between the spokes is flanged downwardly to strengthen the same, such flanged parts gradually running into the respective turned-under metal of the spokes. To strengthen the aforementioned boss the member 6 is pinned and brazed therein, such member having a flanged upper end which is brazed to the boss web. This strengthening member 6 may, however, be fixed in any other desired manner. (*Sealed.*)

PRINTING AND ALLIED MACHINERY.

148,684. D. Goodman, Kettering. Gauges for Cutting Machines. (4 *Figs.*) July 5, 1919.—The invention relates to gauges for use on machines for cutting paper, cardboard and similar material, or for cutting metal, of the kind which act as stops up to which the work is set, and which are adjustable in

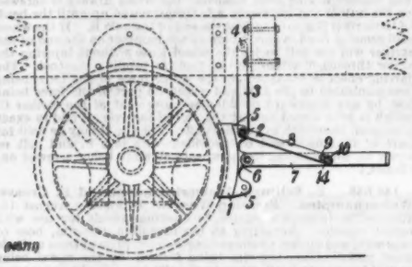


relation to the knife of the machine for determining different lengths of the parts to be cut. The device comprises a gauge bar 1, having therein a longitudinal slot. In its upper face the bar has formed a series of transverse grooves 3. A locking plate 4 has a downwardly-projecting lip adapted to enter any

one of the grooves 3, said plate being fastened down by a screw which passes through a hole in the locking plate and through the slot in the gauge bar 1. The screw, which fits a tapped hole in the machine bed on which the gauge is mounted, prevents movement of the locking plate 4, and when tightened clamps the said plate upon the gauge bar to hold the latter firmly on the bed. When the gauge is to be adjusted in position, the screw is slackened, sufficiently to allow the lip 5 to be raised from the particular groove it has been engaging, whereupon the gauge bar 1 may be moved endwise in either direction, the new position being determined by allowing the lip 5 to enter the appropriate groove in the bar 1, after which the screw is tightened to fasten the gauge. The end 8 of the gauge bar serves as a stop up to which the work may be set. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

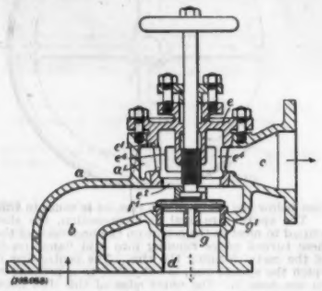
148,711. Dickson and Mann, Limited, Armadale, and J. Cunningham, Bathgate. Brake Blocks. (2 *Figs.*) October 23, 1919.—The invention relates to the suspension of brake blocks for railway rolling-stock. The brake block 1 is suspended at its upper end by means of a bolt 2 from a link 3, pivoted at 4 to the vehicle frame. The brake block 1 is provided with lugs 5 at each end, so that the brake block may be reversed when worn. The brake block 1 is provided midway thereof with a lug 6, which is pivotally connected to the brake pull rod 7. The pull rod 7 is a duplicated link. According to the invention, the pull rod 7 is connected to the upper lug 5 and bolt 2 by means of an inclined link or duplicated link 8 pivotally mounted on the bolt 2 at one end and having a slot 9 at the other end for



the reception of a bolt 10, upon which is mounted a friction device or spring so that relative movement of the link 8 in relation to the pull rod 7 may take place when the brake block 1 is applied to the wheel tread, whilst the friction of the spring is sufficient to retain the link 8 in its position relative to the pull rod 7 after the brake is withdrawn, thus avoiding the possibility of the brake surface of the brake block 1 rubbing against the wheel tread when the brakes are withdrawn. The bolt 10 is provided with a distance piece between the duplicated pull rod 7 and with a washer or disc bearing against one of the links 8 under the action of the spring. The pressure of the spring may be adjusted by the adjustment of the nut 14. (*Accepted August* 11, 1920.)

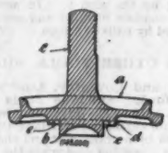
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

148,088. H. B. Scott, Middlesbrough, and Smith's Dock Company, Limited, South Shields. Bye-Pass Valve. (1 *Fig.*) December 1, 1919.—The invention relates to bye-pass valves of the type in which steam or fluid is directed by means of a single valve into either one of two outlet passages, between which the said valve works. The casing *a* is formed with an inlet passage *b* and two outlet passages *c* and *d*. The cover *e* is formed with a tapered hollow plug *e*1 which fits into the casing



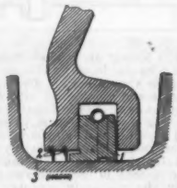
adjacent to the outlet *c* and is formed at the inner end with an opening *e*2 and valve-seating. The extension *e*1 is hollow and is formed with ports *e*4 which communicate with an annular passage *e*3 around the extension and communicating with the outlet *c*. In the extension is the valve spindle, the inner end of which engages with a mushroom valve *f*1 having a rod which works in a guide *g* formed in a valve seating *g*1 mounted in the outlet *d*, while the upper end of the valve spindle works in a gland formed upon the cover *e*. (*Accepted August* 11, 1920.)

148,638. J. Mills, Manchester. Manhole Covers. (3 *Figs.*) July 15, 1919.—The invention refers to mudhole lids and manhole covers of boilers, of the kind wherein the inner face of the cover is provided with a lug which can be gripped in the jaw of the screwing machine, whereby the stud of the lid or cover, usually formed solid with the lid or cover, may be turned or machined in a lathe and screw-threaded more readily and accurately. That face of the lid *a* which comes within the boiler, &c., is formed with a circular projecting and parallel-sided boss *b*, such boss being axially in line with the stud *c* on the opposite side of the lid, the said boss being provided for the purpose of enabling the lid to be concentrically gripped and held



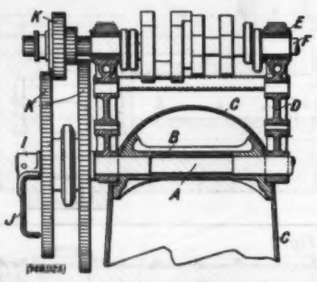
by the jaws of a universal lathe chuck preparatory to first machining the stud and then screwing same. Upon the same face of the lid or cover *a* having the projecting boss *b* is a further projection *d*, in the form of an annular flange, the face of which lies at right angles to the longitudinal axis of the said stud and parallel with the plane of the primary axis of the lid on the joint facing. The said flange *d* will be concentric to the said boss, and the metal of the lid between the boss *b* and flange *d* will be recessed at *e* to allow the jaws of the chuck to make true contact with the face of the flange *d*. (*Accepted August* 11, 1920.)

146,640. Sir C. A. Parsons, Wallsend-on-Tyne, S. S. Cook, Wallsend-on-Tyne, and L. M. Douglas, Wallsend-on-Tyne. Packing Glands. (5 *Figs.*) April 14, 1919.—The invention relates to packing glands for rotating bodies, and particularly for the rotors of steam turbines. The invention consists in providing in a packing gland projections either on the stationary or the rotating member, or on both, said projections having a small clearance from the opposite member, in combination with a stationary balanced divided ring or rings of carbon or the like material in contact with the rotating member.



Within the housing of the gland is provided a stationary balanced divided ring 1 of carbon and fixed to the housing, either on the high or low-pressure side of the ring, are a number of internal-projections 2 extending towards the rotating member 3 and having a small clearance therefrom. Instead of the projections 2 being fixed to the stationary member they may be carried by the rotating member, or, they may be fixed alternately on the rotating and stationary members, giving what is known as a labyrinth packing. These projections are formed with sharpened edges to minimise the effects of any accidental contact. (*Sealed.*)

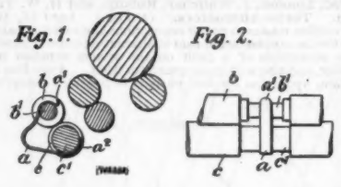
148,025. W. T. Bell, Lincoln, and F. J. Bretherton, Lincoln. Steam Engines. (2 *Figs.*) May 27, 1919.—The invention relates to that class of steam engines for motor vehicles in which the connection of the crankshaft brackets and the cylinder is such that the expanding of the boiler does not alter the distance of the crankshaft from the cylinder. For the purpose of the invention the crankshaft brackets are journalled to the boiler so that the crankshaft brackets can rock and adjust themselves with regard to the cylinder at varying degrees of heat,



whereby any expanding of the boiler will not interfere with or alter the distance of the crankshaft from the cylinders. When a locomotive type of boiler is used a cross-shaft is inserted through the boiler, a crankshaft to the engine is carried in brackets that are journalled on the cross-shaft, and the crankshaft brackets are kept at constant position in relation to the cylinder by stays connected with the cylinder or other part of the engine. A is the cross shaft positioned within a tubular bearing B, which is secured to the boiler C inside of same at the rear end, the cross-shaft A projecting at each end outside the boiler. On these projecting ends of the cross-shaft A, on each side of the boiler, are journalled brackets D, D, the upper ends of which are provided with bearings E, E, which carry the crankshaft F, and the brackets D, D, are each connected by stays to the engine cylinder. The cross shaft A is carried on each side in bearings I secured to the chassis J, and such cross-shaft A and crankshaft F are connected by gearing K, and the crankshaft may also carry the flywheel, the gearing being employed for propulsion, speed and other purposes. (*Sealed.*)

TEXTILE MACHINERY.

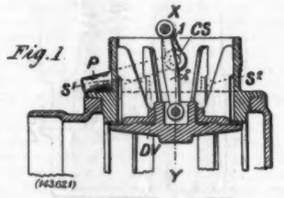
148,668. F. W. Constantine, St. Annes-on-Sea, and T. G. Kay, Bolton. Spinning Machines. (5 *Figs.*) May 24, 1919.—The invention relates to the rollers of spinning, doubling, twisting and like machines. It is well known that one or more of the top rollers in these machines is or are weighted to cause the proper or desired drawing of the thread between the rollers, and for this purpose cumbersome levers and weights are made use of which occupy a large amount of useful space and are somewhat difficult to adjust or to have repairs effected. It has also been proposed to employ spring pressure devices, certain of which have a saddle fitting over the boss of the movable roller, the other end being connected by a spring with a fixed part of the machine, while others have springs acting on saddles fitting over the bosses of both the fixed and movable rollers. The present invention consists in the employment of spring pressure devices for urging



the rollers towards each other, of simple character, one form consisting of a flat leaf spring having one end fitting over the axle or boss of the movable roller and the other end fitting over the boss of the other roller. A modified form consists of two hinged plates with their outer ends fitting over the bosses or axles of the two rollers, a spring acting in conjunction therewith. A flat or leaf spring *a* is employed of such shape that as the two extremities *a*1, *a*2, are moved apart, they will exert pressure on parts, as the rollers of a spinning machine, intervening between them. These outer ends take over the axles *b*1, *c*1, of the top and bottom rollers *b*, *c*, respectively, so that the said top roller *b* is pressed firmly upon or into contact with the bottom roller to effect the drawing actions of the yarns between them. To apply the spring it is only necessary to press it over the axles *b*1, *c*1, so that the curved parts of the outer ends *a*1, *a*2, rest upon the axles *b*1, *c*1. (*Sealed.*)

MISCELLANEOUS.

143,621. S. V. De Bolotoff, Sevenoaks. Valves. (6 *Figs.*) February 24, 1919.—The invention relates to valves and comprises the combination with a reciprocating valve, a guide by which it is guided in its reciprocation, and a shaft, of a crank on the shaft and a connecting rod, the last two constituting a toggle which forms the operative connection between the crank and valve, and of an operating arm or other projection from the shaft and two fixed stops against one of which the projection abuts in the closing of the valve, and against the other of which it abuts in the opening of the valve, the said combination being characterised by the stops, the projection and the toggle being so arranged in relation to one another that the toggle will not only be stopped by the one projection after the valve is shut, in a position of the two links of the toggle wherein they are to that side of a line beyond which the fluid pressure acting on the valve tends to keep them in its tendency to reopen the valve, but will



also be stopped by the other projection, after the valve is open in a position of the two links of the toggle wherein they are to the same side of the said line, beyond which line the fluid pressure acting on the valve tends to keep them if it should tend to reclose the valve. D V is a reciprocating valve. C S is a shaft, 1 a crank on the shaft, and 2 a connecting rod, the last two constituting a toggle which forms the operative connection between the crank and the valve D V. P is the operating arm, secured on the shaft C S, and S1 and S2 two fixed stops, against one of which, S1, the projection P abuts in closing the valve, and against the other, S2, in opening the valve. Stops S1, S2, the projection P and the toggle are so arranged in relation to one another that after the valve is shut the two links 1, 2, are to that side of a line X, Y beyond which the fluid pressure acting on the valve tends to keep them in its tendency to reopen the valve and also when the valve is opened are at the side of the said line, towards which the fluid pressure acting on the valve tends to keep them if it should tend to reclose the valve. (*Sealed.*)

END OF THE ONE HUNDRED AND TENTH VOLUME.

PUBLICATIONS.

NEW PATENT LAW.

The Handbook of Patent Law of all Countries.
By W. P. THOMPSON, F.C.S., M.I.Mech.E., etc., Chartered Patent Agent of Liverpool.
157 pages. Crown Octavo. 1920. K 883
All Countries, 6/-; British Law only, 1/-.
London - - STEVENS & SONS, Ltd.

PATENT AGENTS.

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.
E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
306, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7434. Od 585

Jensen & Son, 8068
CHARTERED PATENT AGENTS,
77, Chancery Lane,
LONDON, W.C. 2.
Telephone: Holborn No. 1349.

John E. Raworth & Moss,
CHARTERED PATENT AGENTS,
75, Victoria Street, Westminster, S.W. 1. 8192

Patents, Inventions, Trade MARKS, DESIGNS.—Advice and Handbook free.—KING'S PATENT AGENCY, LIMITED, 146A, Queen Victoria Street, London. Over 34 years' references. Telephone: Central 682. 9028

PARTNERSHIPS.

Attractive Openings
FOR
ENGINEERS WITH EXPERIENCE AND SUBSTANTIAL CAPITAL.
Wheatley Kirk, Price & Co.
46, Watling Street,
LONDON, E.C. 4.
ESTABLISHED SEVENTY YEARS. 8191

An Established Firm of Public Works Contractors (Western Counties) with £80,000 contracts in hand, REQUIRE a DIRECTOR with £10,000. 10 per cent. Participating Preference Shares offered with salary to suitable incomer taking up active work. Investigation invited.—Particulars from Messrs. ARNOLD & CO. (London), Ltd., 143, Cannon St., E.C. 4. L 321

WANTED, &c.

Hilder Daw, M.E.I.C., M.R.S.I.,
9 & 10, Southampton Street,
Holborn, W.C. 1,
is PREPARED to ADVISE on PROBLEMS arising in connection with Sewage, Civil and Constructional Undertakings.
Telephone: Museum 954. 9065

Important French Firm of Mechanical Engineers, owning modern Works and manufacturing cotton hosiery machinery, WOULD PURCHASE LICENSE for the manufacture of machine-tools, textile or other machinery, for mass production.
Address, ETABLISSEMENTS ADOLPHE BERNARD, La Courneuve, Seine, France. L 95

The Owen Davies Engineering CO., LTD., Ballards Lane, North Finchley, N. 12, having facilities for producing light machine and sheet metal work, are OPEN to CONTRACT for MANUFACTURING ENGINEERING WORK of all descriptions. — Please write, or 'phone Finchley 2194. 8080

Engineer, Resident U.S.A., INVITES ENQUIRIES British Firms desirous obtaining copies of all U.S. Patents, any given subject, promptly as issued; or any service requiring correspondent with some technical knowledge.—Address, L 280, Offices of ENGINEERING.

Pattern Making of all descriptions, modern plant. Inventors' models and patterns a speciality. Estimates given.—FINE CASTINGS LTD., Forest Road, Fishponds, Bristol.

The Proprietors of the Patent No. 128379, for "Improvements in or relating to Ordnance and Projectiles for use therewith," are DESIROUS of ENTERING into ARRANGEMENTS by way of license and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country.—All communications should be addressed in the first instance, to HASELTINE, LAKE & CO., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C. L 322

Engineer with Intimate knowledge of the South Wales and Monmouthshire area, combined with considerable experience in Mechanical and Electrical Engineering, is OPEN to ACT as REPRESENTATIVE in that district, for firms interested in Colliery and Steelworks concerns.
Prepared to work on basis of salary and commission or solely commission.—Address, L 350, Offices of ENGINEERING.

JUST PUBLISHED

(Nets.—All prices are net, postage extra.

In Cloth, with 95 Illustrations in the Text, one Folding Plate and Instruction Chart with 31 Diagrams of Welds. 12s.

SPOT AND ARC WELDING.

By H. A. HORNOR, B.A.

GENERAL CONTENTS.—Materials—Electric Welding, Systems—Spot Welding—Demonstration of Heavy Spot Welding—General Applications of Arc Welding—Discussions on Arc Welding—The Arc Welder—The All-Welded Ships—Theories of Electric Welding—Appendices—Index.

Sixth Edition. Pp. i-xv × 486, with 130 Illustrations. 18s.

THE METALLURGY OF IRON.

By Prof. THOS. TURNER, M.Sc., A.R.S.M., F.I.C.

"Clearly written, nicely illustrated, and practical."—*Engineer.*

Twenty-fourth Edition. Cloth, with Illustrations. 21s.

A MANUAL OF CIVIL ENGINEERING.

By W. J. MACQUORN RANKINE, LL.D., F.R.S.

Comprises—Engineering Surveys, Earthwork, Foundations, Masonry, Carpentry, Metal Work, Roads, Railways, Canals, Rivers, Waterworks, Harbours, &c.

Third Edition. In Crown 8vo. Cloth. Illustrated. 6s.

METHODS OF AIR ANALYSIS.

By J. S. HALDANE, M.D., LL.D., F.R.S.,
Reader in Physiology and Fellow of New College, Oxford.

An Account of Methods of Air Analysis suitable for work in Physiology, Hygiene, Investigations of Mine Air, Flue Gases, Exhaust Gases from Engines, &c.

"A model of conciseness and lucidity . . . should prove invaluable."—*Science and Art of Mining.*

LONDON: CHAS. GRIFFIN & CO., LTD., EXETER STREET, STRAND, W.C. 2.

Splendid! nothing like them

so writes a well-known Engineer.

CYCLOPEDIA
of
CIVIL ENGINEERING.

9 VOLS., PROFUSELY ILLUSTRATED. A MINE OF VALUABLE FACTS.

Produced by The American Technical Society.

Just what you want.

A FREE EXAMINATION OFFER.

A reference library and Training Course combined of great lucrative value, that will help you up and bring success. Written and arranged by the World's leading Engineers, it covers clearly and comprehensively the whole field of "Civil Engineering." You have nothing to lose but everything to gain by filling up the Coupon and posting it without delay to—

SEE BEFORE BUYING.

8975

W. R. HOWELL & CO., 42, THEOBALDS RD., W.C. 1.

Please send me the complete set of "Civil Engineering," 9 Vols. If I retain it I will remit £2 in full payment, or a first payment of £1 1s., and seven further payments of £1 1s. monthly thereafter. Otherwise I will return the complete set within Seven Days.

Name.....

Private Address.....

Date.....

The Broadway Engineering Handbooks.

VOLUME XXVII.

THE STRENGTH OF STRUCTURAL ELEMENTS.

By E. H. SPRAGUE, A.M.Inst.C.E.

"Is to be commended, not so much because it contains anything very new, as because it brings together what is really essential in a convenient form."—*The Contract Journal.*

NARROW CROWN 8vo. 200 PAGES. WITH EXAMPLES, 5 PLATES AND 112 ILLUSTRATIONS.

Price 5s. net (post free, 5s. 6d. Home and Abroad).

PUBLISHED BY 8784

SCOTT, GREENWOOD & SON, 8, Broadway, Ludgate, London, E.C. 4.

The Progress Engineering DESIGN CO., 66, Victoria St., Westminster, S.W. 1, can develop your ideas or advise you on labour saving devices, increasing output or cheapening production. Send us your enquiries. 9055

Repetition Work. — Firms Requiring Paraffin or Petrol Engine Parts, Tappets, Valves, Camshafts, Cylinders and Crankcases, small Marine Reverse Gears, &c., or any high-class work suitable for Precision Boring Mills, Automatics and Capstan Lathes, Casehardening, Cylinder and Precision Grinders, &c., are INVITED to SEND their ENQUIRIES to W. & F. WILLS, Ltd., Bridgewater.

Representative Holding High- class agency of interest to Engineers and Collieries DESIRES one or two ADDITIONAL AGENCIES. Can influence business in Midlands and N. Wales, including two large Railway companies.—Address, L 266, Offices of ENGINEERING.

Wanted, for Reasonably prompt delivery, One Horizontal or Vertical Cross Compound Condensing STEAM ENGINE, I.H.P. 400, Flywheel grooved for 10-12 ropes 1¼ in. diameter. Existing engine room space 60 ft. to 70 ft. Steam pressure 160 lbs. per sq. inch superheated to 450° to 500° F.—Address offers, L 348, Offices of ENGINEERING.

Wanted, Vertical and Hori- zontal PLANING MACHINE in first-class condition, to plane about 18 ft. by 12 ft. with Independent Motor Drive. 3 phase, 25 cycles, and 440 volts. State price, condition and where seen.—Address, VERTICAL, WM. PORTEOUS & CO., Glasgow. L 331

Second-hand Electric Motor CAR LIFT REQUIRED complete, suitable D.C. voltage 240, full particulars.—Address, L 271, Offices of ENGINEERING.

Wanted 20/30 Ton Wagon WEIGHING MACHINE. State price and particulars.—Address, L 314, Offices of ENGINEERING.

Wanted, One Main and Tail Rope HAULAGE GEAR, complete, with 40 B.HP. motor, or thereby, at 500 volts, D.C. Control and Switch Gear, Drums about 2 ft. 6 in. dia. by 1 ft. 8 in. wide.—Address, L 318, Offices of ENGINEERING.

Wanted, One Endless Rope HAULAGE GEAR complete, with 30 B.HP. motor, or thereby, at 500 volts D.C. with Control and Switch Gear preferred. Speed of rope about two miles per hour.—Address, L 319, Offices of ENGINEERING.

Required Immediately, Two 3 ton STEAM TRAVELLING CRANES, new or very good second-hand. Full particulars and price packed F.O.R., for Madras.—Address, L 341, Offices of ENGINEERING.

Wanted, Second-hand, 300 amp. hour STORAGE BATTERY and CHARGING BOOSTER for Dynamo, 12 Kw. 60 amps., 1100 revs. Voltage 200.—Write, WINDOVERS LIMITED, 22, Long Acre, W.C. L 349

AUCTION SALES.

Wheatley Kirk, Price & Co.
(Established 1850).
Valuers
AND AUCTIONEERS OF 8191
ENGINEERING WORKS PLANT AND STOCK.
46, WATLING STREET, LONDON, E.C. 4.
16, ALBERT SQ. 26, COLLINGWOOD ST.,
MANCHESTER. NEWCASTLE-ON-TYNE.
Telephones & Telegrams at each Address.

G. R.

BY ORDER OF THE DISPOSAL BOARD.

Messrs. Worsfold and HAYWARD, are including in a SALE by AUCTION on the 5TH and 6TH JANUARY, 1921,
20 Officers' and Men's HUTS and the CAMP BUILDINGS, also
A SPLENDID GALVANIZED CORRUGATED IRON WORKSHOP WITH PAINTED EXTERIOR,
in five bays, 150 ft. by 100 ft. by 18 ft. to Ridge, fitted with 15 Double Sliding Doors, Well Lighted, containing interior offices and stores, together with an expensive Heating system consisting of Ideal Section Boiler with two Electric Pumps and 26 Radiators.

The latter is situated at the Shakespeare Hall on the main S.R. line from which a siding runs alongside the premises, so that easy facilities exist for removal of goods purchased.
Arrangements can be made for inspection with the Auctioneers previously.
Catalogues can be obtained of the DISPOSAL OFFICER, Eastern Area, 15, Cromwell Road, S. Kensington, and of the AUCTIONEERS, Market Square, Dover. L 336

G. R.

BY ORDER OF THE CONTROLLER OF HIS MAJESTY'S STATIONERY OFFICE.
VALUABLE ELECTRICAL STORES REMOVED FROM FRANCE.
Great Suffolk Street,
London, S.E.

Valuable and Nearly New ELECTRICAL PLANT AND MACHINERY and 18 OIL ENGINES including :—Three ELECTRIC GENERATOR SETS with 33 HP. Keighley Oil Engines and 21 Kw. Castle Dynamos, Two GENERATOR SETS with 6 HP. Keighley Oil Engines, and 3 Kw. Castle Dynamos. A KNIGHLEY-HOLMES MOTOR GENERATOR SET comprising 22 HP. Imperial Oil Engines and 12 Kw. Castle Dynamos, a Lighting Set comprising 5 HP. Lister Oil Engine and Mandsley Dynamo, Two 14 HP. Tangye Oil Engines, 12 H.P. Petter Oil Engine, Two 6 HP. ditto, Two 7 HP. Blackstone ditto, Three 2½ HP. National Oil Engines, 2·3 Kw. Castle Dynamos, 0·6 Kw. Verity Dynamos, 46 ELECTRIC MOTORS 100 to 220 volts, 1 to 6 HP., Shafting, Belting, etc., 14 Marble Switch Boards, 13 Control Boards and Cabinets, Distribution Boards, Storage Cells, Starters, Fuses, Cleats, 40 Mercury Vapour Lamps, Five Electric Ventilating Fans, Three Electrical Copiers and a quantity of Cabling together with a large assortment of Valuable Letterpress and Lithographic Plant and Machinery, which will be sold by Auction by
MR. ROBERT H. BUDDOCK,
on the premises as above on THURSDAY, 6th JANUARY, 1921; may be viewed day prior and morning of Sale, and Catalogues of the Auctioneer, 71, Fleet Street, London, E.C. 4. L 179

Auction Sales continued on page 4.

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.
(Plant and Machinery Section.)

Highly Important Sale of VALUABLE MACHINE TOOLS, OIL ENGINES, GENERATING SETS, ELECTRIC MOTORS, VEGETABLE and FRUIT PRESERVING PLANT, &c.

LYING at MINCHINHAMPTON, LEIGHTERTON and RENDCOMBE (Glos.), and HEREFORD, On TUESDAY, JANUARY 11, at the SUBSCRIPTION ROOMS, STROUD; and on WEDNESDAY, JANUARY 12th, at No. 86 C.S. DEPOT, ROTHERWAS, HEREFORD) comprising:—

LYING at R.A.F. STATION, MINCHINHAMPTON (Glos.),
MACHINE TOOLS, &c.

One 8½ in. CENTRE LATHE, S. S. & S. Gap Bed, by Whitaker & Clapham.
One 6½ in. CENTRE LATHE, S. S. & S. Gap Bed, Denham.
One 3½ in. CENTRE "DRUMMOND" TREADLE LATHE.
One 24 in. VERTICAL DRILLING MACHINE, by Fredk. Pollard & Co.
One 14 in. "NEW CENTURY" DRILLING MACHINE, by Jones and Shipman.
One "SELSON" SHAPING MACHINE, 10 in. stroke.
One UNIVERSAL GRINDING MACHINE, 18 in. by 8 in.
One TWIST DRILL and TOOL GRINDING MACHINE, by H. E. Jackson.
One "FORTUNA" POWER HACK SAW, 6 in. by 6 in.
One DOUBLE-GEARED ARBOR PRESS, by Jones & Shipman.
One CENTRIFUGAL BOOSTER PUMP, 200 gals. per min. capacity, direct coupled to 14½ hp. motor, 230 volts D.C., 1440/1650 R.P.M. with starter.

ELECTRICAL PLANT.

Two 35 K.w. DYNAMOS, 230 volts D.C., 1,100 R.P.M., by Brush Elec. Eng. Co., Ltd.
SWITCHBOARD, comprising two dynamo panels, eight feeder circuit panels, by Crompton.
Two 70 b.hp. SEMI-DIESEL VERTICAL OIL ENGINES, twin cylinder, by Robey.
Four D.C. MOTORS and STARTERS, 230 volts, two 10 b.hp., one 6 b.hp., and one 2 b.hp.
Two ELECTRIC MOTOR FANS, 230 volts, 730 R.P.M.

LYING at R.A.F. STATION, LEIGHTERTON (Glos.),
MACHINE TOOLS, &c.

One 8½ in. CENTRE LATHE by Whitaker & Chapham.
One 6 in. CENTRE LATHE, by Denham.
One 3½ in. CENTRE "DRUMMOND" TREADLE LATHE.
One 26 in. DRILLING MACHINE, by Jones & Shipman, and one 14 in. ditto.
One "ACME" HACK SAW MACHINE.
DOUBLE FORGE and DOUBLE ACTION BELLOWS.
One PLANE IRON GRINDING MACHINE for 24 in. Plane Irons, by J. Sagor & Co., Ltd.
28 HYDRANTS, Shafting, Pulleys, Hangers, &c.

ELECTRICAL PLANT.

Two 35 K.w. DYNAMOS, 4 pole, 850 R.P.M., by the Phœnix Dynamo Co.
One MAIN SWITCHBOARD, comprising four Panels, each 40 in. by 14 in., with Ammeters, Voltmeters, &c., by Brookhurst.
Two 70 b.h.p. HORIZONTAL CRUDE OIL ENGINES, single cyl., by Fielding & Platt.
One 10 b.hp. MOTOR and STARTER, 220 volts, D.C., 1000 R.P.M., by Mawdsley's.
Two 5 hp. Ditto, 220 volts D.C., 30 Amps., 1000 R.P.M., by Electrical Construction Co.
One 2 hp. MOTOR and STARTER, 220 volts D.C., 8·0 Amps., 100 R.P.M., by H. T. Boothroyd & Co., Ltd.
Large Quantity ELECTRIC CABLE, 3/22, 7/20 and 7/16.
One OVERHEAD STRUCTURE for Line Shafting and Countershafting.

LYING at R.A.F. STATION, RENDCOMBE (GLOS.).

MACHINE TOOLS, &c.

One 8 in. CENTRE LATHE, S.S. & S., gap bed by J. Lang & Sons.
One 6 in. CENTRE "DRUMMOND" LATHE, S.S. and S.
Two 3½ in. CENTRE "DRUMMOND" LATHES, gap bed, S.S. & S.
One 20 in. VERTICAL DRILLING MACHINE, by Jones and Shipman.
One 13 in. SENSITIVE DRILLING MACHINE, by F. Pollard, Leicester.
One "SELSON" SHAPING MACHINE, 10 in. Stroke.
One DOUBLE-HEAD GRINDING MACHINE by Luke and Spencer, Manchester.
One "FORTUNA" POWER HACK SAW, 8 in. stroke.
One 36 in. GRINDSTONE, and one 24 in. ditto.
One C.I. BLACKSMITH'S HEARTH, hand-operated fan type, by Alldays and Onions.
One COPPERSMITH'S BLAZING HEARTH, with hand-operated Roots type Blower, by Samuelson & Co.
One WATER STORAGE TANK, 15,000 galls. capacity, iron segments, 9 ft. by 9 ft. bolted.
One WATER RESERVE TANK, 13,000 galls. capacity, pressed Steel segments, 4 ft. by 4 ft., bolted.
One PARAFFIN STORAGE TANK, 1,000 galls. capacity, galv., 8 ft. by 5 ft. by 4 ft.
One Ditto, 4 ft. by 3 ft. by 2 ft. 8 in.
One AIR CYLINDER, 8 ft. long by 7 in. dia., 150 lbs. per sq. in.
One PUMPING SET, comprising Horizontal "Tange" Oil Engine, 16 HP., cylinder 8½ in. dia. by 16 in. stroke, "Worthington Centrifugal Pump, 1,200 r.p.m., 4 in. inlet and outlet.
SHAFTING, Pulleys, Brackets, Belting and Miscellaneous other items.
One OVERHEAD STRUCTURE for Line Shafting and Countershafting.

WOOD-WORKING MACHINERY.

Two 18 in. CIRCULAR SAW BENCHES, by Wadkin, Leicester.
Two 24 in. BAND SAWS by John Pickles and Son.
One SINGLE SPINDLE MOULDING MACHINE, 1 in. spindle, table 2 ft. by 2 ft., by J. Sagar and Co., Halifax.
One PLANE IRON GRINDING MACHINE, to take planes up to 24 in. long, by T. Robinson and Sons, Rochdale.
One BENCH GRINDING MACHINE.

ELECTRICAL PLANT.

Two 16.3 Kw. GENERATING SETS, comprising Horizontal "Petters" Oil Engine, 26 HP., Cylinder 11½ in. dia. by 17 in. stroke, with 16·3 Kw. Belt-driven Dynamo, 68 amps., 240 volts, 1,000 r.p.m., compound wound, by Astor.
Quantity Generating Set Spares.
Seven DOUBLE-PANELLED SWITCHBOARDS, panels 3 ft. by 2 ft. by 1½ in. and 1 ft. 6 in. by 2 ft. by 1½ in. with Voltmeters, ammeters, switches, &c., by Chamberlain and Hickman, and Miscellaneous other items.
One 3½ HP. MOTOR and SWITCH, 220 volts, 14 amps., 1,300 r.p.m.

LYING at No. 86 C.S. DEPOT ROTHERWAS, HEREFORD.
MACHINE TOOLS, &c.

Thirteen "PHILLIPS" PATENT HYDRAULIC LATHES, by Spencer and Sons, Melksham.
Two 8½ in. CENTRE LATHES, S.S. & S., by Milwaukee Machine Tool Co.
One 9 in. CENTRE LATHE, S.S. & S., by Gliddings and Lewis Manufacturing Co., U.S.A.
Four HEAVY 12 in. CENTRE LANG TYPE LATHES, S.S. & S., by Otis Elevator Co.
One 13 in. CENTRE do., by Sociedad Espanola.
One 12½ in. CENTRE BORING LATHE, S.S. & S., by Ward, Haggas, and Smith.
Six 15½ in. CENTRE LATHES, S.S. & S., by Pittsburg Machine Tool Co.
Three HEAVY DUTY 27 in. VERTICAL DRILLING MACHINES, by Wm. Asquith, Ltd.
One 26 in. "NEW CENTURY" VERTICAL DRILLING MACHINE, by Jones and Shipman.
New HYDRAULIC SPRING TESTING MACHINE, 20 tons power, 12 in. stroke, 1,500lbs. working pressure, by Fielding and Platt.
One No. 1 "LUMSDEN" OSCILLATING GRINDER.
One No. 4 "LUMSDEN" TRIPLE-END GRINDER.
One "ACME" PATENT HACKSAW, 14 in. blade, by Wicksteed and Co., Ltd.
One CROSS-CUT SAW BENCH, 18 in. Saw, by J. Sagar and Co., Ltd.
New PELLET ROLLING MACHINE.
One "DRY" TIME-RECORDING CLOCK for 150 numbers.
Three 5-cwt. OVERHEAD TRAVELLING CRANES, 31 ft. 6 in. span, by Herbert Morris, Ltd.
One 5-cwt. Ditto, 31 ft. span.
About 70 YARDS 14 lbs. RAILS in sets of Right and Left hand points, curves, &c.
31 STEEL SLEEPERS, 2 ft. 7 in. by 4 in. by ½ in.
36 PAIRS FISHPLATES for 14 lbs. Rail.

ELECTRICAL PLANT.

Two NEW 216 Kw. MOTOR GENERATING SETS, 322B.HP. Motor 440 Volts A.C., 3-phase, 40 periods, with D.C. Generator, 216 Kw., 8 poles, 600 amps., 775 r.p.m. 180/360 Volt range, by B.T.H. Rugby.
One 20 B.HP. MOTOR, 220 Volts, A.C., 2-phase, 50 cycles, 960 r.p.m.
One 6 HP. MOTOR and STARTER, 200 Volts A.C., 3-phase, 50 periods, 1,000/955 r.p.m., by Siemens Bros.
One "PHŒNIX" PATENT ELECTRIC MAGNET.
Five ONE-TON ELECTRIC OVERHEAD TRAVELLING CRANES, 36 ft. span, by Broadbent and Sons, Ltd., Huddersfield, with two 10 HP. Motors and one 2½ HP. ditto, 200 volts, A.C. 3-phase, 50 periods, by Westinghouse, Manchester.

VEGETABLE and FRUIT PRESERVING PLANT.

One ROTARY POTATO WASHING MACHINE, cylinder 10 ft. by 2 ft. dia. by Mabbott & Co.
One ROTARY POTATO PEELING MACHINE, cyl. 12 ft. long by 3 ft. dia., by Mabbott & Co.
Two NEW ROCKER TYPE FRUIT and VEGETABLE WASHING MACHINES, 4 ft. by 3 ft. by 1 ft. 6 in., by Tomlinsons (Rochdale), Ltd.
One BELT-DRIVEN FRUIT-SLICING and SHREDDING MACHINE, and ONE BELT-DRIVEN CABBAGE CUTTING MACHINE, by Tomlinsons (Rochdale), Ltd.
Two BELT-DRIVEN AUTOMATIC STEAM-HEATED COOKING MACHINES, by Harrison, Carter, Ltd.

IMPORTANT.—The Lots at Minchinhampton, Leighterton and Rendcombe, which will be sold at Stroud, should be inspected PRIOR TO DAY OF SALE.

Further particulars and Catalogues free, obtainable (when ready) from the Auctioneer, Mr.

CHARLES D. PHILLIPS,
Princes Chambers, St. John's Square, Cardiff.
Telegrams, "Realiza," Cardiff. Telephone, 317 Cardiff. L 313

STEAM USERS. I HATE YOU

not to know all about the

"SKATOSKALO"

PATENT PNEUMATIC SCALING TOOL

for Babcock, Stirling, and ALL Water-Tube and Lancashire Boilers, Economisers, Evaporators and Condensers, also for Rust Removing.

Supplied to the Admiralty, War and India Office, also the principal Firms and Electricity Undertakings in the United Kingdom.

List will be sent explaining its advantages, together with names of users by applying to—

£350

FRANK GILMAN,

Sole Maker, 9, WESTFIELD RD., BIRMINGHAM.

FOR SALE.

Seventeen New High Pressure AIR RECEIVERS, 5 ft. high, 17 in. dia. T. DAVIES & SON, Railway Ironworks, West Gorton, Manchester. K 871

Presses.—Four Johnson Filter PRESSES (60 Plate size 3 ft. by 3 ft.), complete with 214 plates, cheap for prompt sale. —Apply, BOX 808, ROBERTSON & SCOTT, Advertising Agents, Edinburgh. L 270

For Sale, One Holroyd Double Head SLOT DRILLING MACHINE. One Kearns No. 4 BORING AND FACING MACHINE.—G. & J. WEIR, Ltd., Cathcart, Glasgow. L 316

One No. 5 Bliss - Styles FLYWHEEL POWER PRESS, 30 ton, Blanking, Shallow Forming, &c., in new condition, can be seen in London.—Address, L 326, Offices of ENGINEERING.

Tracing Cloth at approx. 40 per cent. below Manufacturer's prices. Superior British make, in rolls 30 and 40 in. wide by standard length. Perfect condition. Sample on enquiry. Small or large lots supplied. FORTIS & PARTNERS, 60, Queen Victoria Street, E.C. 4. L 324

Whitakers (Engineers) Ltd., HORSFORTH, LEEDS, can OFFER for PROMPT DELIVERY, subject to being unsold, ONE 12 TON WHITAKER CRANE TYPE EXCAVATOR, now being rebuilt. L 306

For Sale, about 30 Tons 75 lbs. FLAT BOTTOM RAILS; also one SET of CROSSINGS.—Write, BOX F 63, LEE AND NIGHTINGALE, Advert. Offices, Liverpool. L 344

Cranes for Sale.

One 5-ton Steam Locomotive Shunting Crane by Smith of Rodley; all motions 4 ft. 8½ in. gauge, jib 22 ft. 6 in. long, steel carriage.
One 5-ton Locomotive Crane by Isles, jib about 28 ft. long, all motions.
One 5/6-ton Locomotive Shunting Crane by Henderson, all motions.
Two 3-ton Locomotive Shunting Cranes by Smith of Rodley, all motions, jibs 21 ft. 6 in. long.
One 3-ton Locomotive Crane by Smith of Rodley, all motions, jib 23 ft. 6 in. long.
GEORGE COHEN SONS & CO., 600, Commercial Road, London, E. 14. L 300

10 in. by 72 in. Landis GRINDER, with self-contained drive, practically new.
No. 9 Herbert COMBINATION TURRET LATHES.
New 6 in. stroke SLOTTING MACHINE, self-acting feeds.
Gardner New 22 in. CRANK PIN TURNING MACHINE.
No. 1 La Pointe BROACHING MACHINE.
6A and 6A Potter & Johnston CHUCKING AUTOMATICS.
14 in. stroke, 4 ft. bed, TRAVELLING HEAD SHAPING MACHINE.
Redman HIGH SPEED PLANER, 10 ft. by 5 ft. by 5 ft., with four toolboxes, three speed self-contained countershaft. New.
Redman HIGH SPEED PLANER, 12 ft. by 3½ ft. by 3½ ft., with three toolboxes and single speed countershaft. New.
37 in. HIGH SPEED RADIAL DRILLING and TAPPING MACHINE.

USED MACHINES.

No. 13 Natco MULTIPLE SPINDLE DRILL.
Archdale VERTICAL MILLER, table 44 in. by 12½ in., single pulley drive.
VERTICAL BORING & TURNING MILLS, 24 in. and 30 in. sizes, by Bullard, King and Rogers.
Webster & Bennett 30 in. DUPLEX VERTICAL BORING and TURNING MILL.
7A SUNDERLAND GEAR PLANERS, capacity 18 in. diam., for spur and spiral gears. 7776

JOHN MACNAB (MACHINERY), LTD., Hyde. Tel.: 78 Hyde.
London Office: 7, King St., Cheapside, E.C. 2.
Birmingham Office: 40, Bennett's Hill.
Manchester Warehouse: Sophia St., Rochdale Road.

300 Kw. Power Plant for DISPOSAL. Westinghouse-Diesel ELECTRIC SET, 300 Kw., 250 volts D.C. Compound Wound. Immediate delivery.—Apply, J. G. WALTHEW, Consulting Engineer, 30, Spring Gardens, Manchester. K 734

Steel-Framed Skeleton BUILDING FOR SALE, in nearly new condition with a clear floor space of about 200 ft. by 31 ft., a height to eaves of about 15 feet and with a curved roof rising about 6 ft., suitable for Engineer's Workshop, Garage or Stores, consisting of 17 stanchions 7 in. by 6 in. on each side about 12 ft. 6 in. apart and a centre stanchion to each end, 17 steel roof trusses. 3 in by 3 in. angle iron purlins and side framing. 8 steel casements 12 ft. by 4 ft. (18 lights to each) and 4 pair steel framed sliding doors. The Gald. Corrugated Iron for roof and ends can also be supplied and the greater portion of ditto for sides. Ready for immediate despatch. Price £2250. —Apply, MATTHEWS BROS., 47, Hallam Street, Portland Place, London, W.1. H 927

Platelayers' Tools, etc.

1000 Beater Picks.
3000 Spanners for ¾ in. bolts.
250 Iron Shod Ash Levers.
700 Crow and Point Bars.
50 Jim Crows.
100 Navvy Barrows.

THOS. W. WARD, LTD., Sheffield. L 180

FOR SALE.

Horizontal Compound Drop Valve ENGINE, 11 in. and 19 in. cyls., 26 in. stroke, by Marshall Sons & Co.
Horizontal Cross-Compound ENGINE, 17 in. and 28 in. cyls., 36 in. stroke, by Ruston, Proctor & Co., Ltd.
Cross Compound Horizontal Corliss ENGINE, 15 in. and 24 in. cyls., 36 in. stroke, by D. Adamson and Co., Ltd.
Two Cross Compound Horizontal ENGINES, 12½ in. and 20 in. cyls., 36 in. stroke, by Robey & Co.
Cross Compound ENGINE, 11 in and 17½ in. cyls., 20 in. stroke, by J. Fowler & Co. 9064
Vertical Compound Steam ENGINE, 8 in. and 12 in. cyls., 8 in. stroke, by Robey & Co., direct coupled to dynamo, 105 volts, 190 amps., 300 revs.

CATALOGUE of Stock MACHINERY, 5-6000 LOTS, free on application. Inspection invited.
THOS. W. WARD, LTD., ALBION WORKS, Tel. "Forward, Sheffield." SHEFFIELD.

For Sale.

One Brand New Vertical Single-acting Three throw ram PUMP, with gun-metal rams 6 in. dia. by 6 in. stroke. Fitted with bored guides complete with raw hide pinion for motor and air vessel suction and delivery branches 4½ in. dia. Motor required 17½ HP. at 1150 revs.
The pump is geared to run at 165 revs. and will pump up to 7000 gallons per hour.
Price £395.
Apply BRAITHWAITE & CO., Crown Bridge Works, West Bromwich. L 165

Vacuum Pumps for Delivery from STOCK in London.
Two Horizontal Belt-driven Single-stage Slide Valve Vacuum Pumps, cylinder 300 m.m., stroke 200 m.m., speed 200 r.p.m., capacity 180. cubic feet per minute.
Two, as above, cylinder 350 m.m., stroke 200 m.m., speed 200 r.p.m., 245 cubic feet per minute.
One, as above, cylinder 400 m.m., stroke 300 m.m., speed 180 r.p.m., 430 cubic feet per minute.
THE BURCKHARDT ENGINEERING WORKS, 26, Victoria Street, Westminster, S.W.1.
Telephone, Victoria 1672 and 9735.
WORKS—Basle, Switzerland. K 776

Hugh Wood & Co., Ltd., DEPT. N., NEWCASTLE-ON-TYNE.
Tel. Add.: "Huwod," Newcastle-on-Tyne.
Tel.: 980 Central, Newcastle-on-Tyne.
Have available for Immediate Delivery,
AUXILIARY HAULAGE GEARS. ELECTRIC, COMPRESSED AIR, or STEAM-DRIVEN.
Several 15 H.P. ELECTRICALLY-DRIVEN HAULERS, 500 volts, 50 periods, or alternatively 500 volts, D.C. equipment.
Several 10 H.P. ELECTRICALLY-DRIVEN HAULERS, complete with 500 volts, 50 periods, or alternatively 500 volts, D.C. equipment.
Several STEAM or COMPRESSED AIR HAULAGE ENGINES, double drums, cylinders 7 in. bore by 9 in. stroke.
One 3½ ton Jeffrey Electric Accumulator Standard Gauge LOCOMOTIVE.
One 2½ ton Jeffrey Electric Trolley Standard Gauge LOCOMOTIVE.
Also available for Immediate Delivery.
Several "Huwod" Portable Compressed Air-driven CENTRIFUGAL PUMPS.
"Huwod" Pneumatic Pick Axes, Coal Cutter Hose, &c., &c.
Also for Early Delivery.
One 24 in. by 24 in. Jeffrey SINGLE ROLL CRUSHER or BREAKER, having a capacity of, approximately, 70 tons of coal per hour.
One Jeffrey SWING HAMMER PULVERIZER having a capacity of 60 tons of coal ¼ in. to dust per hour.
Jeffrey Self-propelling WAGON and TRUCK LOADER, suitable for loading coal, coke, sand or similar material. 6-74
HUGH WOOD & CO., LTD.

For Sale, &c., continued on page 131.

For Continuation of Small Advertisements see page 131.

INDEX TO ADVERTISEMENTS.

A-J Manufacturing Co. ... 79
Abbott & Co. (Newarx), Ltd. ... 94
Aeroplane Corporation, Ltd. ... 32
Ashworthie, John, Ltd. ... 24
Adamson, D., & Co., Ltd. ... 88
Agricultural & General Engineers Ltd. 69
Allen Shipbuilding Co., Ltd. ... 96
Aldrich Pump Co. 107
Alexander, Herbert & Co. ... 132
Allen-Liversidge, Ltd. ... 23 & 24
Allen, W. H., Son & Co., Ltd. ... 69
Allied Steel Makers and Founders Ltd. 88
Amsler, A. J. & Co. 97
Anderson, D. & Son, Ltd. ... 103
Anderson Grice Co., Ltd. ... 100
Angus Geo., & Co. Ltd. 6
Armstrongs & Main, Ltd. ... 106
Armstrong, Stevens & Son, ... 86
Armstrong, Whitworth and Co., Ltd. 7
Arrel, Sir W., & Co., Ltd. ... 194
Assoc. British Machine Tool Makers, Ltd. 70
Aster Engineering Co., Ltd. ... 91
Asquith, Wm., Ltd. 96
Atkins, R. C., & Co., Ins. ... 113
Atlas Diesel Co., Ltd. 28
Atlas Metal & Alloys Co. ... 114
Aveling & Porter, Ltd. 1
Bagnall, W. G., Ltd., 24 & 132
Balderston & Co., Ltd. 90
Barker, Spink, Lease & Co. ... 86
Barnard, E. S. & Son 194
Bassett-Lowke, Ltd. 123
Bath, T. & Co. 96
Beardmore, Wm., & Co., Ltd. ... 18
Beckenham Foundry 192
Bedford Engineering Co. ... 9
Beebe, A. 192
Beeston & Stevenson, Ltd. ... 31
Beldam Pkg. & Rubber Co. ... 98
Bellamy, John, Ltd. 1
Bell's United Asbestos Co. ... 42
Belmont Iron Works 192
Bergius Launch & Engine Co. 101
Berry, F., & Sons. 41
Berry, Henry, & Co., Ltd. ... 67
Bertrams, Ltd. 95
Betts Machine Company 98
Billington & Newton, Ltd. ... 66
Birm. R. C. & W. Co., Ltd. ... 22
Blundell's London Copper and Brass Works, Ltd, ... 129
Bodley Bros. & Co. 97
Bolton, Thos. & Sons, Ltd. ... 132
Booth, Jos., & Bros., Ltd. ... 96
Boston Scale & Machine Co. ... 104
Boulton & Paul, Ltd. 113
Boving & Co., Ltd. 110
Bowran, Robert & Co. 107
Braby, Fred., & Co., Ltd. ... 9
Brett's Patent Lifter Co. ... 119
Brette Stamping Co. Ltd. ... 131
British Fibre Cement Wks. ... 48
British Hickman Roller Co. ... 98
British Oil Products Co. ... 18
British Rolling Mills, Ltd. ... 129
British Ropeway Eng. Co. ... 24
Brit. Steam Specialties ... 99
Brit. Thomson-Houston Co., Ltd. 13
Broadbent, T., & Sons, Ltd. ... 83
Brookes & Adams 111
Broom & Wade, Ltd. 86
Brotherhood, P., Ltd. 69
Broughton Copper Co., Ltd. ... 130
Brown, David and Sons (Huddersfield) Ltd. 47
Brandrit, Joseph 92
Brush Elec. Eng. Co., Ltd. ... 36
Buck & Hickman, Ltd. 80
Budenberg Gauge Co., Ltd. ... 97
Buhring's Pat. W. P. Co. ... 98
Bullivant & Co., Ltd. 98
Bull's Metal & Melloid Co. ... 86
Burckhardt Eng. Works, ... 115
Burmeister & Wain, Ltd. ... 70
Burnet, Lindsey & Co. 191
Burton, Griffiths & Co. 81
Butcher, H., & Co. 1
Butler, Sam., & Co., Ltd. ... 88
Butterfield, W. F., Ltd. 97
Butterley Co., Ltd. 119
Butterworth Bros. Ltd. 1
Caird & Rayner 16
Caledonian Tel. Co., Ltd. ... 71
Cambridge & Paul Inst. Co. ... 1
Cammell Laird & Co., Ltd. ... 27
Campbell & Calderwood 132
Campbell Gas Engine Co. ... 40
Campbell & Isherwood, Ltd. ... 93
Campbell's Hunter, Ltd. 1
Carborundum Co., Ltd. 90
Carruthers, J. H., & Co. 131
Cawood, G. E. & Co. 27
Chadwick, W., & Co., Ltd. ... 104
Chambers Scott & Co. 5
Chesterfield Tube Co., Ltd. ... 18
Churchill, C., & Co., Ltd. 97 & 113
Citroen Gear Co., Ltd. 111
Clark, Geo. & Son (Hull) ... 126
Clarke, Chapman & Co., Ltd. ... 90
Clay Cross Co., Ltd. 129
Clayton, Son, & Co., Ltd. ... 94
Clement Stevens Pat. Eng. Co., Ltd. 120
Cleveland Bridge & Eng. Co. ... 99
Clifton & Baird, Ltd. 126
Clyde Structural Iron Co. ... 126
Cochran & Co. (A.) Ltd. 1 & 17
Cockburn, A., & Co. 27
Cookburns, Ltd. 18
Colse, Henry J. Ltd. 128
Cole, Marchant & Morley, Ltd. 133
Coltman, H., & Sons 97
Consol'ted Brake & Eng. Co. ... 98
Cooke, H. P. 112
Cowans, Sheldon & Co. 87
Craddock, Walter 12
Craig, A. F., & Co., Ltd. 96
Craig & Donald, Ltd. 17
Crane-Bennett Ltd. 137
Crockatt, W. & Sons, Ltd. ... 26
Crofts (Engineers), Ltd. 8
Crosby Valve & Eng. Co. ... 124
Crossley Bros., Ltd. 77
Crowther & Osborn, Ltd. ... 97
Dalgliah, A. & W. 97
Daniels, T. H. & J. Ltd. 86
Danks, H. & T. (Netherton) ... 94
Darlington Forge Ltd. (The) ... 133
Davidson & Co., Ltd. 44
Davis Brothers, Ltd. 116
Davis Furnace Co. 100
Davis & Primrose, Ltd. 92
Davy Brothers, Ltd. 58
Dawson & Downie, Ltd. 106
Day, Summers & Co., Ltd. ... 43
Delta Metal Co., Ltd. 125
Dempster, Moore & Co., Ltd. ... 125
Dennystown Forge Co. 16
Dixon, Joseph. Crucible Co. ... 89
Doncaster, Taylor & Co. 13
Drum Engineering Co. 100
Drummond Bros. Ltd. 132
Drysdale & Co., Ltd. 84
Dudbridge Ironworks, Ltd. ... 81
Dunlop & Ranken, Ltd. 87
Dunlop Rubber Co., Ltd. 81
East Ferry Road Engineering Works Co., Ltd. 18
Edmeston, A., & Sons, ... 113
Electric Construction Co. ... 82
Electric Control, Ltd. 126
Electro-Metals, Ltd. 14
Elliot, Geo., & Co., Ltd. 5
Ellison, W. T., & Co. 133
Empire Roller Bearings Co. ... 19
Engineering Supplies Ltd. ... 127
English Electric Co., Ltd. ... 75
Entwisle & Gass, Ltd. 98
Evans, Joseph, & Sons, ... 129
Everitt & Co. 106
Fairley, James, & Sons 121
Farrar Boiler Works, Ltd. ... 126
Fawcett Preston & Co., Ltd. ... 94
Ferodo Ltd. 63
Findlay, Alex., & Co., Ltd. ... 125
Finney, Geo. & Co. 109
Firth, T., & Sons, Ltd. 42
Fisher & Ludlow, Ltd. 80
Fleming & Ferguson, Ltd. ... 7
Forbes Bros. 101
Fowler, John, & Co. (Leeds) ... 104
Fuller, Horsey, Sons & Cassell ... 1
Fuller-Lehigh Co. 90
Gartsherrie Eng. & Forge Co. ... 1
Gibbons Bros., Ltd. 86
Gilman, Frank 4
Glasgow Railway Eng. Co. ... 1
Glenfield & Kennedy, Ltd. ... 38
Globe Pneum. Eng. Co., Ltd. ... 39
Goodwin Barsby & Co. 123
Gorge Shafting & Eng. Co. ... 130
Grafton & Co. 12
Griplock Washer Ltd. 12
Grice, Grice & Son, Ltd. 97
Grieve, John & Co. 80
Griffin, Chas. 9
Grimson-Russell Co. 40
Grover & Co., Ltd. 27
Gunther, W., & Sons. 122
Gutta Percha & Rubber Ltd. ... 1
Haldan, W., & Co., Ltd. 94
Hale, Thos. L., Ltd. 83
Halesowen Steel Co., Ltd. ... 9
Hall, J. & R., Ltd. 23
Hall, F., & Sons, Ltd. 110
Hall, J. F. & Co., Ltd. 110
Hamilton, Archibald & Co. ... 137
Hampden & Deane Ltd. 18
Hampton & Bobbe, Ltd. 108
Hanworthy Eng. Co. Ltd. 90
Hands, John, & Sons, Ltd. ... 111
Hardy & Padmore, Ltd. 84
Harris, F. W. 25
Harris Pat. Filters Ltd. 24
Hart, Thos., Ltd. 94
Hartnell, Wilson & Co., Ltd. ... 126
Harvey, G. A., Ltd. 18
Haslam Foundry & Eng. Co. ... 117
Hawthorn, R. & W., Leslie and Co., Ltd. ... ... 1 & 119
Head, Wrightson & Co. 1 & 69
Heath & Co., Ltd. 27
Heath & Sorena 102
Heavy Stampings, Ltd. 93
Henderson & Glass 92
Hendry, James 96
Herbert, A., Ltd. ... 24 & 129
Heywood, S. H., & Co., Ltd. ... 1
Hick, Hargreaves & Co., ... 125
Higginbottom & Mannock ... 72
Higgs Bros. 109
Hill, W. W. Son, & Wallace, Ltd. 93
Hindley, E. S., & Son 24 & 128
Hirst, Ibbetson & Taylor ... 100
Hoffmann Mfg. Co., Ltd. 93
Hollings & Orset, Ltd. 9
Hope, Henry, & Sons 6
Holcrofts St el F ndry Co. ... 114
Hordern & Mason 126
Horne Engineering Co. 94
Howell, W. E. & Co. 9
Howell & Co., Ltd. 132
Hoyt Metal Co., Ltd. 69
Hudson, Thos., Ltd. 126
Hudswell, Clarke & Co., Ltd. ... 126
Hughes & Lancaster, Ltd. ... 133
Humphreys & Glasgow 69
Hunslet Engine Co., Ltd. 119
Hurst, Nelson & Co., Ltd. 90
Hyatt Ltd. 123
Igranic Electric Co., Ltd. 99
India Rubber, Gutta Percha & Telegraph Wks. Co. Ltd. ... 126
International G. E. Co. Inc. ... 78
Ironite Co., Ltd. 19
Jackson, F. A., & Co., Ltd. 23
Jacobs Manufacturing Co. 99
Jardine, John, Ltd. 96
Jenkins, W. J., & Co. 99
Johnson Rich., Clapham and Morris, Ltd. 88
Jones & Lamson Machine Co. 104
Kaye, Jos. & Sons, Ltd. 123
Keay, R. O. & J. Ltd. 108
Kenyon, A., & Co. 89
Kermodes, Ltd. 1
Kirby Banks Screw Co. Ltd. ... 91
Kirkaldy, John, Ltd. 1
Kirkstall Forge Co., Ltd. 134
Knap Conrad 14
Kvaener Brug 114
Lanarkshire steel Co., Ltd. ... 111
Lancaster & Tonge, Ltd. 101
Lea Recorder Co., Ltd. 16
Leathers Co. (Alt.) Ltd. 125
Leeds Eng. and Hydraulic Co., Ltd. 96
Leeds Forge Co., Ltd. 116 & 118
Lees, T. & R. 101
Lidgerwood Mfr. Co. 123
Llewellans Machine Co. 117
Lockwood & Carlisle, Ltd. ... 122
Lodge Plugs Ltd. 86
Lonken Company, Ltd. 19
Lonita, Ltd. 132
Lysaght, John, Ltd. 91
McClintic Marshall Products Co. 83
McGowan Wild, & Co. 29
McGraw Hill Publish'g Co. ... 129
McGregor, Gow, & Holland, Ltd. 116
McKechnie, Bros., Ltd. 8
McKenzie, Holland & Worthington Power Signal Co. ... 19
McKie & Baxter 121
McLachlan & Co., Ltd. 97
Maclaren Bros. Ltd. 27
McNeil, C., Ltd. 39
Machinery & Steels, Ltd. 22
Macrae, A. B. 40
Maden & Co., Ltd. 39
Malcolm & Allan, Ltd. 99
Manchester Steam Users Association 9
Manning, Maxwell & Moore ... 1
Mann 105
Manning, Wardle & Co., Ltd. ... 1
Marshall Fleming & Co., Ltd. ... 95
Marshall, Sons & Co., Ltd. ... 134
Mason Regulator Co. 127
Massey, B. & S. Ltd. 116
Mavor & Coulson, Ltd. 95
Maxted & Knotts, Ltd. 1
Maxwell & Page 126
Maycock 17
Meldrums Ltd. 82
Metallic Manufacturing Co. ... 93
Metropolitan Vickers Electrical Co., Ltd. 40
Michell Bearings Ltd. 93
Midland Railway Carriage and Wagon Co., Ltd. 127
Mild Steel Castings, Ltd. ... 110
Mirrlees Watson Co., Ltd. ... 45
Morden, S. H. & Co., Ltd. ... 7
Moteurs National Cie Des ... 126
Motherwell Bridge Co. Ltd. ... 92
Muir, Wm., & Co., Ltd. 108
Mumford, A. G. Ltd. 1, 81 & 93
Munning, H. Ltd. 128
Murray, McVlanzie & Co. 89
Musgrave & Co., Ltd. 1
Napier Bros., Ltd. 86
Newall's Insulation Co., Ld ... 99
Newcastle Alloys Co. 106
Newcastle Shipbuilding Co. ... 116
Newton, Sloane, & Mitchell ... 110
Newton, Chambers & Co. ... 120
Nichols Pump & Eng. Co. 126
Niles-Bement-Pond Co. 33
Noble & Lund, Ltd. 86
Normand, Augustin 1
Northern Crane Works 9
Notcutt, W. P. Ltd. 18
Oakey, J. & Sons, Ltd. 101
Osborn, Samuel & Co., ... 32
Paisleys Ltd. 13
Parkinson, J., & Son 108
Parrott, G. 108
Partington Steel & Iron Co. ... 42
Patent Die-Casting Co. Ltd. ... 119
Pat. Lightning Crusher Co. ... 119
Paterson, Eng. Co., Ltd. 94
Paul, Matthew & Co., Ltd. 1
Pearn, P., & Co., Ltd. 29
Peckett & Sons, Ltd. 119
Pegler Bros. & Co., Ltd. 92
Perman & Co., Ltd. 101
Petters, Ltd. 1
Piggott, Thos. & Co., Ltd. 1
Platt, S. Ltd. 93
Playar, W. & J. 9
Pleck Foundry Co., Ltd. 101
Plenty & Son, Ltd. 1
Pott, Cassels & Williamson ... 93
Power Gas Corporation, Ltd. ... 103
Pratchitt Bros. 99
Precision Gauges, Ltd. 49
Priestman Bros. Ltd. 107
Principe & Co. 108
Proctor, J., Ltd. 98
Pulsometer Eng. Co., Ltd. ... 124
Ransomes, A., & Co., Ltd. 6
Ransome Machinery Co. (1920), Ltd. 93
Ransomes & Rapier, Ltd. 130
Rapid Magnetting Mch. Co. ... 127
Reader, E., & Sons, Ltd. 19
Reay Gearworks, Ltd. 122
Redpath, Brown & Co. 126
Rees Roturbo Mfg. Co. 118
Reid Gear Co. 98
Reyrolle, A., & Co., Ltd. 122
Rhodes Manufacturing Co. ... 126
Richards, Bd., & Sons, Ltd ... 92
Richards, J. H., & Co., Ltd. ... 88
Richardsons, Westgarth Co. ... 131
Richmond Gas Stove Co. 118
Robey & Co., Ltd. 29
Robson, John (Shipley) Ltd. ... 20
Roe & Harrison, Ltd. 124
Rosser & Russell, Ltd. 1
Royles Limited 1
Russell, G. & Co., Ltd. 1 & 134
Ruston & Hornsby, Ltd. 47
Sands, Geo. & Son, Ltd. 17
Sankey, Joseph, & Sons Ltd ... 96
Scott, Greenwood, & Co. 1
Scottish Stamping Eng. Co., Ltd 94
Scottish Tube Co., Ltd. 1
Segors, Ltd. 18
Shanks, Thomas, & Co. 129
Shaw, W., & Co., ... 94
Shepard Electric Crane and Hoist Co. 28
Shore, Inst. & Mfg. Co. 100
Siebe, Gorman, & Co., Ltd. ... 123
Simon-Carves, Ltd. 14
Sisson, W., & Co., Ltd. 119
Skefko Ball Bearing Co. 80
Skinner Chuck Co. 114
Sleeper & Hartley, Inc. 112
Smethwick Stamping Co. 86
Smidth, F. L. & Co., Ltd. 6
Smith, L. & Sons 64
Smith & Coventry, Ltd. 91
Smith & Pearson, Ltd. 128
Smith, Barker, Willson Co. ... 91
Smith Bros. & Hill, Ltd. 127
Smith, Sydney & Sons 126
Somes, W. & Co. 1
Sparklets & Gen. Mfg. Co. 1
Spencer-Somerset, Ltd. 1 & 18
Spencer, John, Ltd. 86
Standerd & Oswald Steels (Engineers) Ltd. ... 80 & 121
Standard P. R. & Eng. Co. ... 125
Steel Belt Conveyors Ltd. ... 117
Steel Co of Scotland Ltd. 12
Steel Pipe Co., Ltd. 98
Stephenson, Robert & Co. 6
Sterne, L., & Co., Ltd. 91
Sterna Ltd. 18
Steven, A. & F. 97
Stirk & Strathern 126
Stewart, Duncan & Co., Ld. ... 54
Stewarts & Lloyd's Ltd. 1 & 76
Stone J., & Co., Ltd. 80
Stothert & Pitt, Ltd. 125
Sturtevant Eng. Co. Ltd. 132
Sudron, Thos, & Co., Ld. 98
Summerson, T., & Sons 98
Superheater Corp'tion, Ltd. ... 127
Sutcliffe Bros 128
Sutcliffe Vent. & Drying Co. Ltd. 108
Swift, George, & Sons, Ltd ... 75
Taylor, Chas (Birm.), Ltd. ... 67
Taylor & Challen, Ltd. 1
Terry, Herbert, & Sons Ltd. ... 129
Terry Steam Turbine Co. 62
Thermotank Co. 20
Thompson, John (W'hamp'n) ... 97 & 98
Thomas & Bishop, Ltd. 102
Thornycroft, John, I. 81
Tickle, John & Co., Ltd. 96
Timbrell & Wright Machine Tool and Eng. Co. Ltd. ... 106
Tinker, Shenton, & Co., Ld. ... 126
Tomey, J., & Sons, Ltd. 98
Trier Bros., Ltd. 126
Tubes Ltd., ... 101
Tullis, D. & J., Ltd 110
Tullis, John, & Sons, Ltd. ... 126
Turnbull, A., & Co., Ltd. 126
Turner Bros. Asbestos Co. ... 14
Twells Patent Valve Gear Co. ... 125
Uehling Instrument Co. 134
United Water Softener 61
Universal Machinery Corp. Ltd. 68
Utting, S. 140
Vacuum Brake Co., Ltd. 118
Valor Co., Ltd. 111
Variable Speed Gear Ltd. 49
Vaughan Crane Co., Ltd. 123
Vibration Specialty Co. 126
Vickers Limited ... ... 64 & 65
Victoria Brass Foundry 106
Vosper & Co. Ltd 1
Wadkin & Co. 64
Walker, W. A., & Co 106
Walker, James, & Co. 74
Wallwork Henry, & Co. 19
Ward, H. W., & Co., Ltd. 127
Ward, Thos. W., Ltd. 68
Weir, G. & J., Ltd. 61
Weldless Chains Ltd. 1
Wellman Smith Owen Eng. Corp. Ltd. 10
Wells, A. C., & Co. 99
Worf Conrad 1
Wesson, W. & Co., Ltd. 98
West, H. J. & Co., Ltd. 18
Westinghouse Brake and Saxby Signal Co., Ltd. 127
Westminster Tool & Misc. Co. 99
Wharton, H. Ltd 11
Whitaker, D. 101
Whitaker's (Eagleware) Ltd ... 133
White Jacoby & Co., Ltd. 98
White, Ed. & Sons, ... 126
White's Injectors Ltd. 130
Wigglesworth, F. & Co. 62
Wiley, James, & Sons 92
Willcox, W. H. & Co., Ltd. ... 5
Williams, J. H. & Co. 41
Wilson, H., & Co. 8
Wilson, William, & Co. 109
Wilt Twist Drill Coy. of Canada, Ltd. 115
Winnett, G. P., Ltd. 99
Winn, Chas. & Co. 18
Winn, W., Martin & Co. 44
Wood, Henry, & Co., Ltd. 98
Woodite Company 101
Worthington-Simpson, Ltd ... 19
Wright, John, & Co. 88
Wrist's Forge & Eng. Co. 129
Yarrow & Co., Ltd. 1
Yorkshire Engine Co. 119
Yates & Thom, Ltd. 62
Youngs 132
Zenith Carburettor Co. Ltd. ... 104

"Willcox" Semi-Rotary Wing PUMPS, Lift and force. Double or quadruple action

Leather, Hair, Cotter, Balata, &c., BELTINGS, Also "Balatite" (Reg. Trade Mark) BELTING.

Also

"JONES-WILLCOX" PATENT WIRE-BOUND HOSE

Non-Rubber

Willcox's

Requisites for the Engineer

including Specialities as illustrated, also "Penberthy" Regrinding &c. Valves, Packings of every description, Tools, etc.

WRITE FOR ILLUSTRATED LISTS.

W. H. WILLCOX & CO. LTD.,

32-38 Southwark Street, LONDON, S.E.1

TELEGRAPHIC ADDRESS: WILLCOX, SOUTHWARK STREET, LONDON.

OILS & GREASES for all classes of machinery.

"Penberthy" Automatic and Autopositive INJECTORS

For low, medium or high pressure boiler feeding.

"Willcox-Jointite" JOINTINGS, for steam, petrol, &c., joints.

7753

GEORGE ELLIOT & CO., LTD.,

MAKERS OF ALL DESCRIPTIONS OF WIRE ROPES.

MANUFACTURERS OF Od 9109

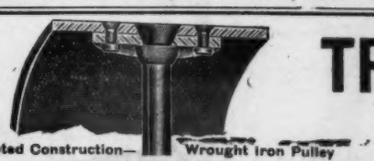
LANG'S LAY WIRE ROPES

Office: 16, GREAT GEORGE STREET, WESTMINSTER, LONDON.

LANG'S LAY WIRE ROPE WHEN NEW.

LANG'S LAY WIRE ROPE WHEN WORN.

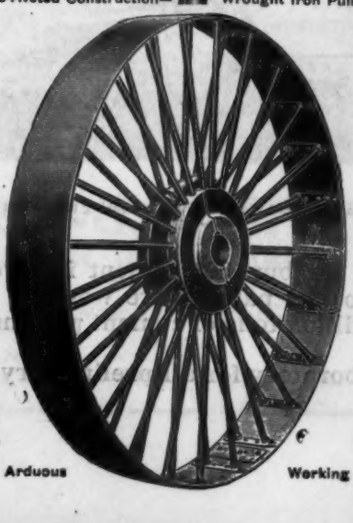
ECONOMICAL POWER TRANSMISSION.



Treble-rivetted Construction— Wrought Iron Pulley

SHAFTING.
COUPLINGS.
BEARINGS.
FIXINGS.

CLUTCHES.
GEAR WHEELS.
ROPE PULLEYS.
SPEED CHANGES.



Crofts ENGINEERS LTD.

Telephone—Bradford 4901 (4 lines).

Bradford

Telegrams—"CROFTERS, Bradford."

Quotations on Application.

Prompt Deliveries.

For Arduous Working Conditions.

4803

RANSOME'S

SAW-MILL Machinery.

Cask-making Machinery.

NEWARK-ON-TRENT, England.

LONDON Office: 63, Queen Victoria Street, E.C. 4.

6814

F. L. SMIDTH & CO. LTD.

Consulting and Contracting Engineers,

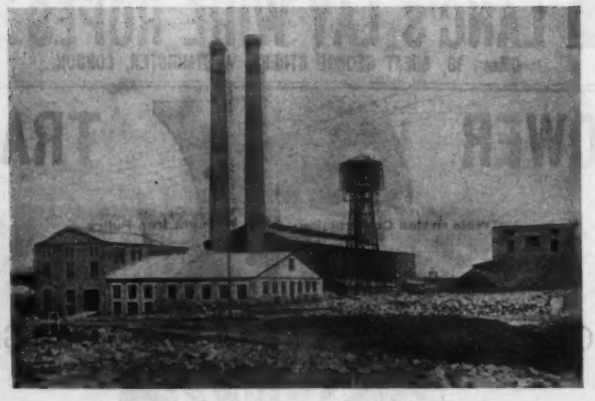
TELEGRAMS: CHALKIMESS ESTRAND LONDON. **20, ESSEX STREET, LONDON, W.C. 2.** TELEPHONE: CENTRAL 2126.

Associated with F. L. Smidth & Co., Copenhagen.

ENGINEERING WORKS AT LUTON, COPENHAGEN, NEW YORK,

PORTLAND CEMENT WORKS

ROTARY KILNS
DRYERS
ELEVATORS
SHAKING CONVEYORS
EXCAVATORS
EXILOR PACKERS
BRICK-MAKING MACHINES



CRUSHERS
ROLLER MILLS
KOMINORS
TUBE MILLS
STEEL BALLS
CYLPEBS
FLINT PEBBLES

Portland Cement Works in Russia, working to our Wet Process.

8426

We have supplied 40 ROTARY KILNS for burning cement in Great Britain, The Dominions and Colonies, and more than 300 ROTARY KILNS to our patents are working in all parts of the world, producing about 8 million tons of cement per annum.

Own trial plant and laboratory for all preliminary examinations and tests.

BUCKET DREDGERS,
HOPPER and BARGE LOADING, BOW and STERN WELL.

COMBINED BUCKET AND PUMP DREDGERS,
WITH HYDRAULIC JET and IMPROVED ROTARY CUTTERS for CLAY and HARD MATERIALS.

HOPPER BARGES, TUGS, and FERRY STEAMERS.

ESTABLISHED ... ... 1878.

PATENT CUTTER HOPPER DREDGERS

SUCTION PUMP DREDGERS
TO DISCHARGE INTO THEIR OWN HOPPERS, INTO BARGES, or ASHORE THROUGH FLOATING PIPES.

TRAILING SUCTION HOPPER DREDGERS.
NEW BUCKETS, LINKS, PINS, GEARING, &c., SUPPLIED FOR EXISTING DREDGERS. Od 1988

LONDON OFFICE:
91, VICTORIA STREET, S.W. 1.
TEL. VIC. 6094.

FLEMING & FERGUSON, LD., PAISLEY, NEAR **GLASGOW.**

SHEETS

ARMCO REG. TRADE MARK INGOT IRON

ALL GRADES and FINISHES of SHEETS, ALSO CULVERTS and FLUMES.

GUARANTEED 99·84% COMMERCIALLY PURE IRON.
HIGHEST RESISTANCE TO CORROSION, LONGEST LIFE, TOUGH & DUCTILE.
Sole Agents for Allied Companies producing Armco Ingot Iron Products

S. H. MORDEN & CO., LTD.
18, DARTMOUTH STREET, WESTMINSTER, LONDON, S.W.1.

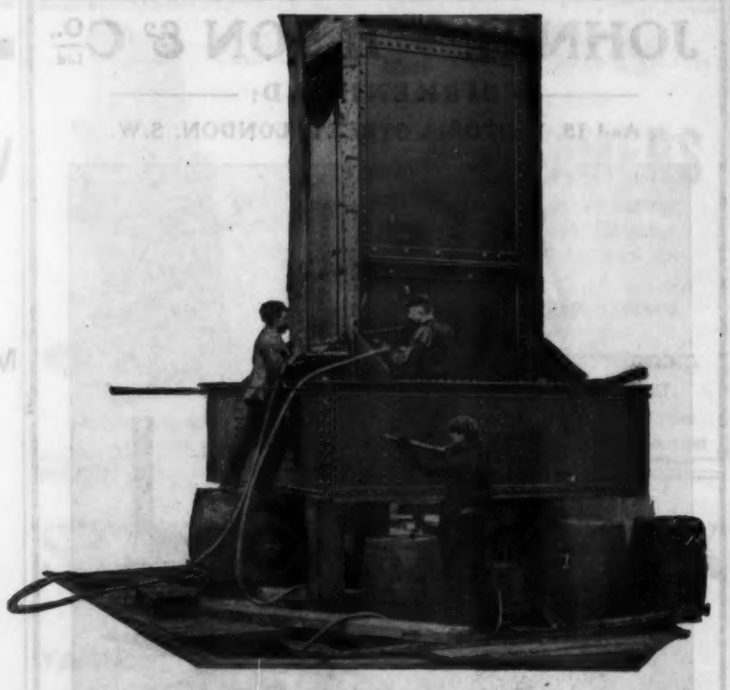
Also "ARMCO" STEEL, ELECTRICAL and AUTO. SHEETS.

TRADE MARK

A.W.
PNEUMATIC TOOLS.

MADE THROUGHOUT OF BEST STEEL.
MINIMUM VIBRATION.
MAXIMUM EFFICIENCY.
LIGHT BUT POWERFUL.
LOW AIR CONSUMPTION.
FEW PARTS.
SIMPLE DESIGN.
EVERYTHING INTERCHANGEABLE.

A.W. IS THE BEST.



SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD.,
Central Commercial Department, 10, Great George Street, Westminster, S.W. 1.

Telegrams: "Arwhitcoy, Parl, London." Telephone: Victoria 4010.

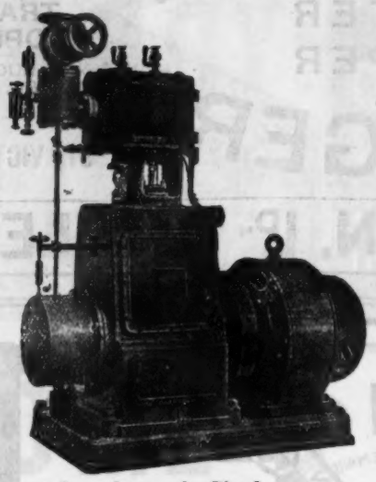
DISTRICT OFFICES:—

BIRMINGHAM: 111, New Street.
MANCHESTER: 5, John Dalton Street.
NEWCASTLE-UPON-TYNE: Pilgrim House, Pilgrim Street.
GLASGOW: 137a, St. Vincent Street.
LEEDS: Pearl Chambers, East Parade.

ENCLOSED HIGH-SPEED ENGINES.

FORCED LUBRICATION.

For Direct Coupling to FANS, DYNAMOS, PUMPS, &c.



These Engines embody all the latest developments suggested by up-to-date experience and research, and being designed on liberal lines throughout can always be relied upon even under most severe conditions.

Full particulars and prices of Single Engines or Combined Sets on application.

On ADMIRALTY LIST. 3059

MUSGRAVE & Co., LTD., Engineers,

BELFAST,
MANCHESTER: 42, Deansgate.
CARDIFF: 24, Queen St.
LONDON: Sardinia House, Kingsway.

Telegrams:—CENTIGRAD.
CENTIGRAD.
CENTIGRAD.
MUSGRAVE, HOLBORN

Codes:—LIEBER'S; A.B.C., 5th *Edition*. ENGINEERING TELEGRAPH, 2nd *Edition*.

EXTRUDED
METAL RODS & SECTIONS

Manufactured to customers' specifications and designs in
Naval Brass, Manganese Bronze, Forgeable Alloys, High-speed Screwing Brass, and High-strength Bronzes.

INGOTS to any MIXTURE with analysis GUARANTEED in GUNMETAL, PHOSPHOR BRONZE & WHITE METAL.

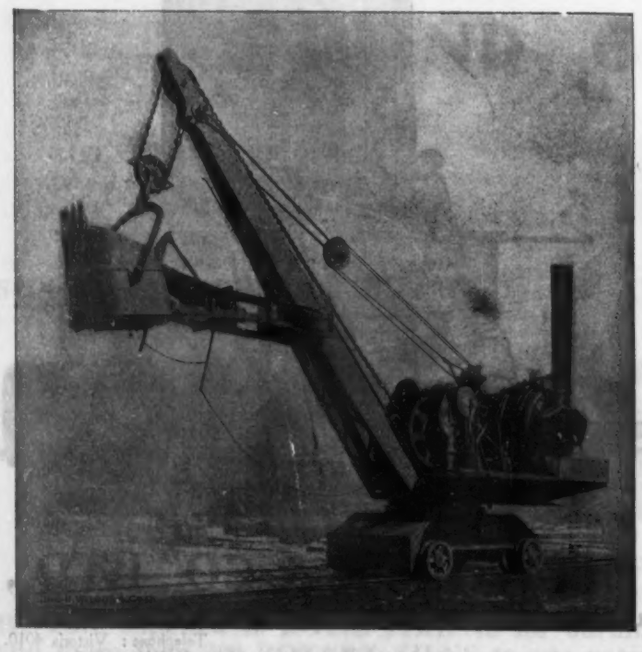
PHOSPHOR COPPER AND PHOSPHOR TIN.
VELVETO AND TANK BRAND ANTIFRICTION METALS. 8625

McKECHNIE BROTHERS,

Copper Smelters, Brass Rod & Metal Manufacturers LTD.
METAL WORKS, ROTTON PARK STREET, **BIRMINGHAM.**
Telephone Nos.—381, Edgbaston, 4 lines.
Telegrams—"McKechnie, Birmingham."
Codes: Lieber's 5 Letter, ABC (5th & 6th editions). Marconi and Private.
SMELTING WORKS:
WIDNES, LANCS.

JOHN H. WILSON & Co., Ltd.

BIRKENHEAD,
And 15, VICTORIA STREET, LONDON, S.W.

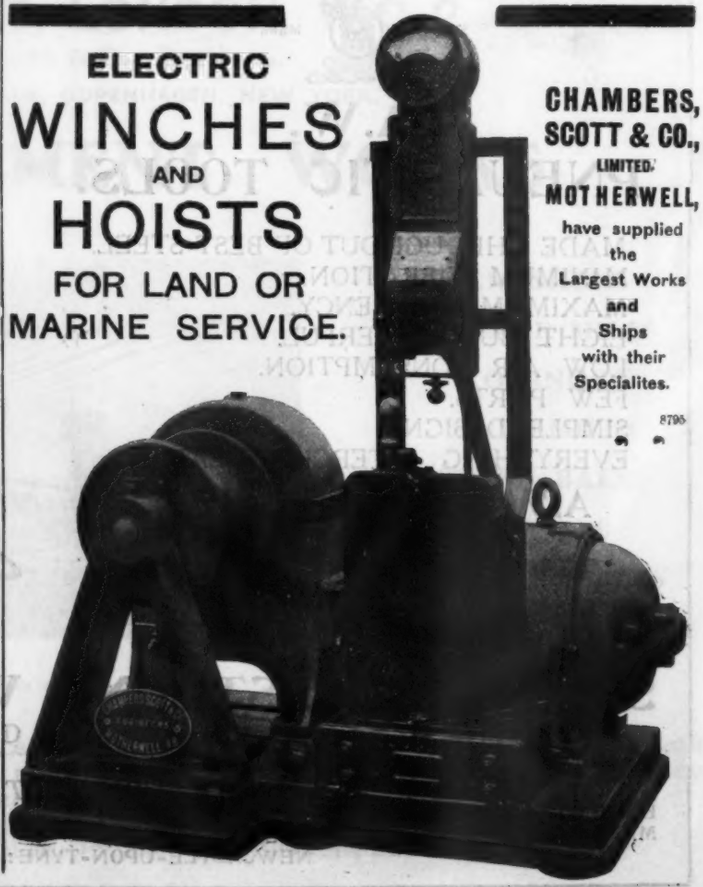


LOCOMOTIVE CRANES (STEAM AND ELECTRIC).
CRANE-NAVVIES, GRABS, AND SHIPS DECK MACHINERY.
5464
LISTS of Standard Sizes on Application.

ELECTRIC
WINCHES
AND
HOISTS
FOR LAND OR MARINE SERVICE.

CHAMBERS, SCOTT & CO., LIMITED. MOTHERWELL, have supplied the Largest Works and Ships with their Specialites.

8795



Tele. Cranes, Bedford. 'Phone, 33, Bedford.

BEDFORD

BEDFORD·ENGINEERING COMPANY 8133

BEDFORD ENGLAND

FOR

HYDRAULIC MACHINERY

SEND TO

HOLLINGS & GUEST, LTD.,

THIMBLE MILL LANE,

BIRMINGHAM,

ENGLAND. 8887

LOOK OUT for NEXT WEEK'S DISPLAY.

ELECTRIC HOISTS

AND

Electric Travelling

CRANES

Made in Canada. 8918

CATALOGUES FREE.

NORTHERN CRANE WORKS,

Limited,

WALKERVILLE, ONT., CANADA.

HALESOWEN STEEL Co LTD

HALESOWEN

BIRMINGHAM

Bright Drawn Steel Manufacturers with Output of 3000 Tons Monthly.

Rounds. 3/16 in.-5 in.

Hexagons. .312 in.-2.757 in. a/f.

Squares. 3/4 in. - 2 in.

All the above Sections manufactured in any quality, and to any Specification or Tests. 8976

FORGING HAMMER. List GF/06.

PLAYER'S

Patent Pneumatic

POWER HAMMERS

For Forging, Planishing, Rivetting, Sheet Metal and Panel Beating, Swaging, Drawing Down, and for all Purposes.

SEE LISTS GF/06, AP/06, PH/06.

W. & J. PLAYER

Smithfield Works, SHERLOCK STREET, BIRMINGHAM. 7800

Telegrams—METHOD, B'HAM. Telephone—MIDLAND 1402

STEEL PLATE WORK

OF EVERY DESCRIPTION.

TANKS.

HOPPERS.

CHIMNEYS. 8044

BUNKERS.

SPIRAL CHUTES.

F. BRABY & CO., Ltd.,

Works at:— *Constructional Engineers.*

LONDON : GLASGOW : FALKIRK : LIVERPOOL : BRISTOL.

Head Office:—352-364, EUSTON ROAD, LONDON, N.W. 1.

A BARREL ON APPROVAL FOR THE ASKING.

A barrel of Super Screwol is waiting for you. A note on your business heading will bring it on approval, carriage paid. If you do not like it send the unused portion back to us. No charge will be made. We will even pay the return carriage as well.

Super Screwol is too good to remain unknown or untried by you. For drilling, cutting, boring and turning it has no equal. It is a soluble oil—95 per cent, water 5 per cent. oil, It does not rust, clog or separate. It preserves the life of the tool increases output, it is antiseptic to Government standard and it is used by the largest engineering establishments (names on request) in the world.

Send a note for a barrel of Super Screwol on approval now, whilst you have the matter in mind. You have everything to gain by this trial and nothing to lose.

STERNS LTD.

56, Royal London House,
Finsbury Square, E.C.

"Measurement generally leads to economy, in anything."
Is anything more important to-day than economy in Coal?

TO USERS OF CHAIN-GRATE STOKERS!

WHY NOT CONVERT ALL YOUR CHAIN-GRATES into COAL MEASURERS?

Every Chain-Grate Stoker is nine-tenths of a Coal Measurer already, and it only requires the addition of the small appliance known as the LEA COAL METER to make it complete.

This Machine, which works on the same principle as the LEA WATER RECORDER & INTEGRATOR, is driven by the Stoker itself, and automatically counts up the cubic feet of coal burnt on each grate.

One of its most useful features is:—That it measures the coal "JUST AS IT IS BURNT." Hence the rate of combustion per sq. ft. of grate per hour can quickly be determined at any time.

Write for full particulars to

The LEA RECORDER Co. Ltd., 28, Deansgate, Manchester.

The Woodfield Electrostacker

TO OPERATE: Lift a Lever

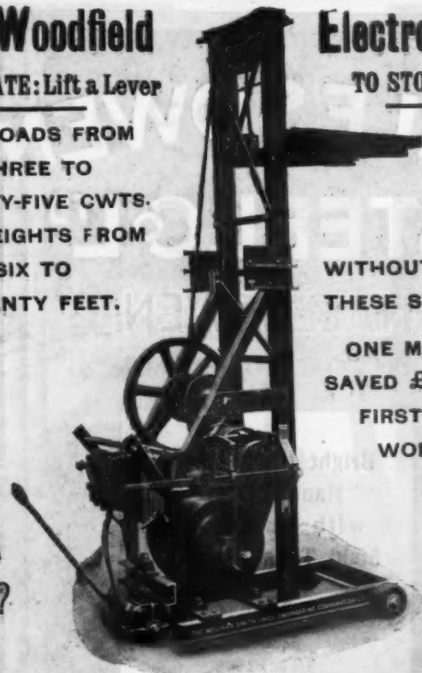
TO STOP: Let Go.

FOR LOADS FROM THREE TO TWENTY-FIVE CWTS. FOR HEIGHTS FROM SIX TO TWENTY FEET.

YOUR WAREHOUSE IS NOT COMPLETE WITHOUT ONE OF THESE STACKERS.

ONE MACHINE SAVED £600 ON THE FIRST YEAR'S WORKING.

WHY NOT GIVE ONE A TRIAL?



PRICES, ETC., ON REQUEST.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD.

KING'S HOUSE, KINGSWAY, LONDON, W.C. 2.
WORKS: DARLASTON, SOUTH STAFFS.

Telephones:
HOLBORN 1782 & 2588.
DARLASTON 87 (3 LINES).

Telegrams:
PRINCIPIUM, WESTCENT, LONDON.
ENJASMITA, DARLASTON.

FURNACES

B&S

BEESTON & STEVENSON
LIMITED.

OPEN HEARTH MELTING FURNACES. REHEATING FURNACES.

SHEET AND TINPLATE MILL AND ANNEALING FURNACES.
PRESS FORGE FURNACES.
CORE DRYING, STAMPING,
STEEL FOUNDRY ANNEALING
AND ALL TYPES OF FURNACES
EITHER COAL OR GAS FIRED.

LLANELLY. CARMARTHENSHIRE.

We are Experts in Gear Drives for Electric Rolling Mills

Electric Driving of Rolling Mills has made greater progress on the Continent than it has here, and the leading plants there have been fitted with

Citroën Gears

The experience we have obtained with these installations is unique, and is at the disposal of all interested in Rolling Mill Equipment. We invite correspondence on this subject, and will send the Citroën Gear Catalogue, which has a special section dealing with this form of drive, on application.

Data of Rolling Mill gears shown, supplied for Electric Drive.

Normal load	2000 HP.
Maximum load	5000 HP.
Speeds	190 & 30 r.p.m.
Diameter of wheel	18 ft. 0 in.
Weight of wheel	50 tons.

THE CITROËN GEAR CO. Ltd.
22, Buckingham Gate, LONDON, S.W. 1.
Telephone: Victoria 7193.
Telegrams: "Hélical, Sowest, London."

E.I.W. 8557

THEY STARTED TOGETHER;
lowering EQUAL loads.
SURELY!!
the rest is obvious.

GRAVITY Lowering. *HAND Lowering.*

Capacities ½ to 5 Ton, Gravity Lowering type.
„ ½ to 10 Ton, Ordinary type.

H. WHARTON Lim.

ON THIS WE STAND 8733

REDDISH, A DEAL *Stockport, ENGLAND.*

— OR FALL —

SIEMENS (S M S) PROCESS
ESTD TRADE MARK 1872
"HALLSIDE"

CONTRACTORS TO—
BRITISH ADMIRALTY, WAR DEPT., and FOREIGN and COLONIAL GOVERNMENTS.

Manufacturers of—

MILD STEEL PLATES, ANGLES, Zed Bars, Tees and all forms of Sectional Bars required for Ship, Boiler, and Bridge Building, and other constructive purposes.

CASTINGS of all kinds and largest sizes for Ship Stems, Sterns, Posts, Anchors, Rudders, &c.

RAILS, BILLETS, FORGINGS.

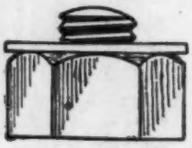
AXLES of highest quality, to meet the requirements of Home and Colonial Railways.

TYRES.—Locomotive Carriage and Wagon, to all requirements.

SPECIAL STEEL of all kinds for constructive purposes.

THE . . .
STEEL COMPANY of SCOTLAND
LIMITED.
23, ROYAL EXCHANGE SQUARE,
GLASGOW.
TELEGRAPH ADDRESS "STEEL" GLASGOW.
8314

YOU CAN SAVE 200% BY USING
THE "GRIPLOCK" WASHER



As Supplied to:
TYNE DOCK ENGINEERING CO., South Shields.
SCOTTISH ENGINEERING AGENCY, Glasgow.
BRUSH ELEC. ENGINEERING CO., Loughborough.
J. BROWN & CO., LTD., Sheffield.

It is an Absolutely Safe Lock and supersedes Lock Nuts, Split Pins, Spring Washers, etc.

For Particulars apply— 8751
The MANAGER, GRIPLOCK WASHER, LTD., 6a, Tudor Street, Blackfriars, LONDON, E.C. 4.

No. 1340 Hand Hydraulic Test Pump arranged to test four jobs simultaneously with shut off cocks and relief valves to each connection, and also relief valve with lever and weight to limit the pressure applied to the jobs, suitable for pressures up to 700 lbs. per square inch. 8454

HAND PUMPS

Of all kinds for Ships and for General Purposes in Cast Iron, Brass, Copper, Gun Metal, White Metal and Acid Resisting Metal.

ESTABLISHED 1832.

ON ADMIRALTY LIST.

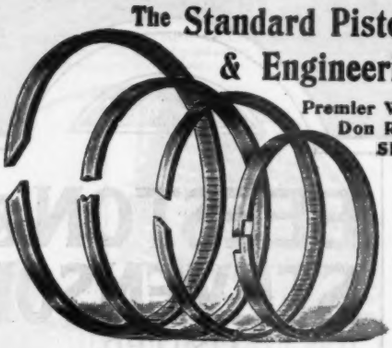
Telephone:—29 Hamilton.
Telegrams:—"Pumps, Hamilton."

DOWNTON, TAYLOR & Co.
HAMILTON BRASSFOUNDRY.
HAMILTON, SCOTLAND.

JOHN OAKEY & SONS, Ltd.
GENUINE EMERY, EMERY WHEELS
EMERY CLOTH, For all Purposes.
Wellington Mills, GLASS & FLINT PAPERS,
WESTMINSTER BRIDGE ROAD, 1396
LONDON, S.E. 1. BLACK LEAD, &c.

HAMMERED CAST IRON PISTON RINGS
(by the Davy-Robertson Process).

All sizes from 2½ in. to 72 in.
In our Special Piston Ring Iron.
Quick Delivery.
Low Prices.



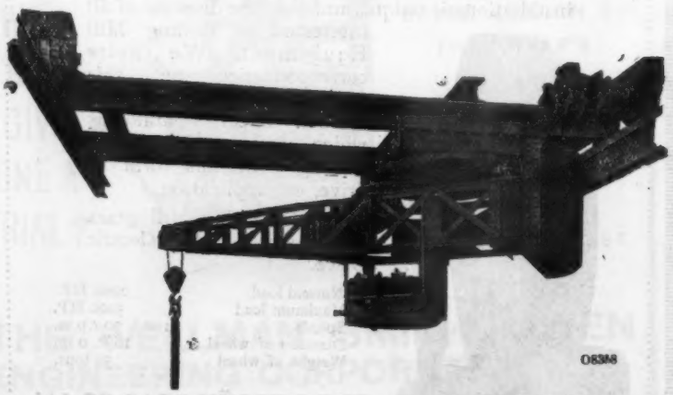
The Standard Piston Ring & Engineering Co., Ltd.,
Premier Works, Don Road,
SHEFFIELD.
8338
Telephone: No. 2149.
Telegrams: Ocean, Sheffield.

GRAFTON & CO.
CONTRACTORS TO H.M. GOVERNMENT,
CYCLOPS WORKS,
Telegrams—Grafton, Bedford. **BEDFORD.**

Illustrated Descriptive Price List free on 8190

SILVER MEDAL, Inventions Exhibition London, 1885. GOLD MEDAL, Paris, 1900.
GRAND PRIX and GOLD MEDAL, Franco-British Exhibition, London, 1908.
GRAND PRIX, Buenos Aires Exhibition, 1910. 4991

HIGGINBOTTOM & MANNOCK, LD.
Crown Iron Works, West Gorton, MANCHESTER.
Telegrams:—CROWN, GORTONBROOK.



O8388

Electric Cranes, Hoists, Capstans, Winches, Traversers, Transporters, Hauling Machinery and Hand Cranes, Hand and Power Runways.

ALL ELECTRIC
OR
ELECTRO-PNEUMATIC

POWER SIGNALLING.

D.-C. AND A.-C. TRACK CIRCUITING

AND MECHANICAL LEVER LOCKING A SPECIALITY.

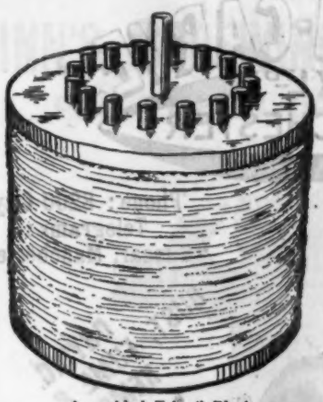
THREE-POSITION SIGNALS.

The McKENZIE, HOLLAND & WESTINGHOUSE POWER SIGNAL CO., Ltd.,

58, VICTORIA STREET, LONDON, S.W.

Telegrams: "POWERSIG, SOWEST, LONDON." 7333

Telephone: VICTORIA 4760 (3 lines).



Assembled Fabroil Blank.

Why Fabroil Pinions are so successful in service.

Steel shrouds and bolts prevent expansion of the cotton body.

Accurately generated teeth ensure smooth running.

Teeth are strong, resilient and silent in operation.

Fabroil Pinions are not affected by steam, moisture, heat, dryness, or any other conditions of service, that so often prove ruinous to metallic and other non-metallic pinions.

Write for illustrated list E.G. 3112 on Fabroil Pinions.

The British Thomson-Houston Co., Ltd.,
Electrical Engineers and Manufacturers, 8290
Head Office and Works - - Rugby, England.

PAISLEYS OVERALLS

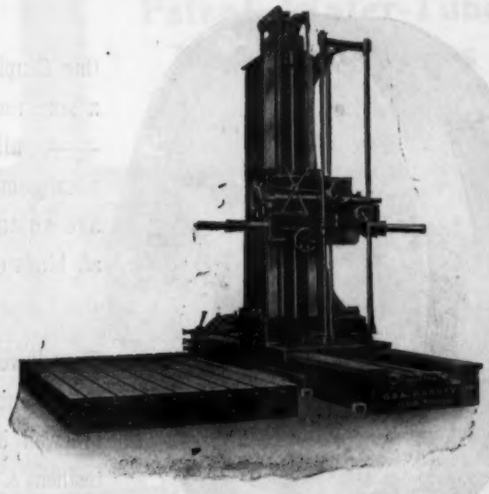
Are celebrated throughout Great Britain and are known to Engineers over the whole world for their DURABILITY.

SPECIAL QUOTATIONS FOR QUANTITIES.

Blue Dongaree Boiler Suits, 14/6, 17/6. Jackets, 7/3, 9/-. Bib Trousers, 8/3, 10/6.
Brown Denim Boiler Suits, 14/6, 17/6, 18/6. Jackets, 7/9, 10/-.
Bib Trousers, 8/9, 11/6.
Brown Jean Boiler Suits, light weight and very tough, 21/-. Jackets, 10/-.
Bib Trousers, 11/6. Khaki Drill Boiler Suits, 14/6, 17/6. Engineers' Serge Jackets, 11/6, All Wool, 16/6, 22/6. White Boiler Suits, 18/6.
Engineers' Serge Trousers, 16/6, All Wool, 22/6. 6735
INSPECTORS' BOILER SUITS in Drab Jean, double knees and elbows, 25/-
Boiler Suits made to measure, 2/6 extra.

PAISLEYS LIMITED, 72 to 96, Jamaica St. GLASGOW.

HARVEY



Horizontal Drilling, Tapping, & Boring Machines.
Spindles 2", 2½", 3", 3½", 4", 5", 6" Dia.

G. & A. HARVEY, LTD.
ALBION WORKS,
GOVAN, GLASGOW.

Telegrams: "GANDAH." 8236

SIMON-CARVES LTD
MANCHESTER

A. P. Dept.,
20, Mount Street,
Manchester.

'Phone: 8200 City.
Telegrams:
"Simcar, Manchester."

MINE FANS.
HEATING & VENTILATING.
HUMIDIFYING.

DUST, DRYING, FUME & STEAM REMOVAL.

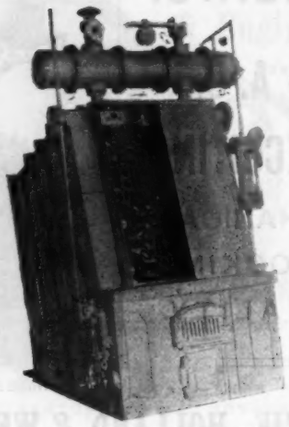
FORCES AND FORGE PLANTS, GAS EXHAUSTERS.

FORCED, INDUCED AND EJECTOR DRAUGHT.

ASK FOR CATALOGUE. 8770 ENQUIRIES INVITED.

"Root" Water-Tube Steam Boiler with "Knap's" Patent Improvements.
ALL BRITISH MANUFACTURE.
Suitable for the Highest Pressures.
30 HP. Boiler in Iron Casing.

All sections bolted together.

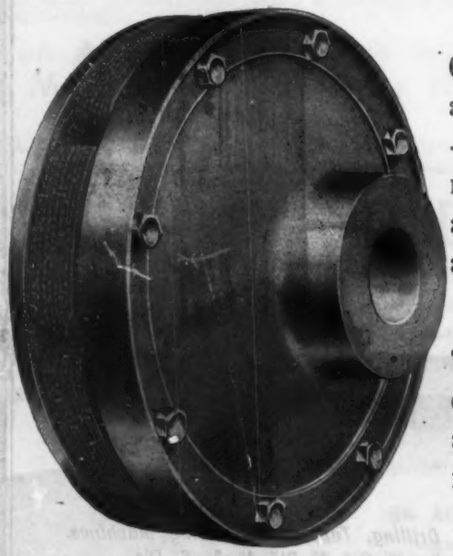


Can be erected by unskilled labour.

Sections under 56 Kilogrammes. 8924

SOLE MAKERS:
CONRAD KNAP & Co., LTD.,
11, Queen Victoria Street, London, E.C. 4.

FLEXIBLE SHAFT COUPLINGS



Our Couplings are a sure remedy for —— all —— misalignments and are suitable for all kinds of drives.

They have a first-class finish and are well balanced, resilient & reliable.

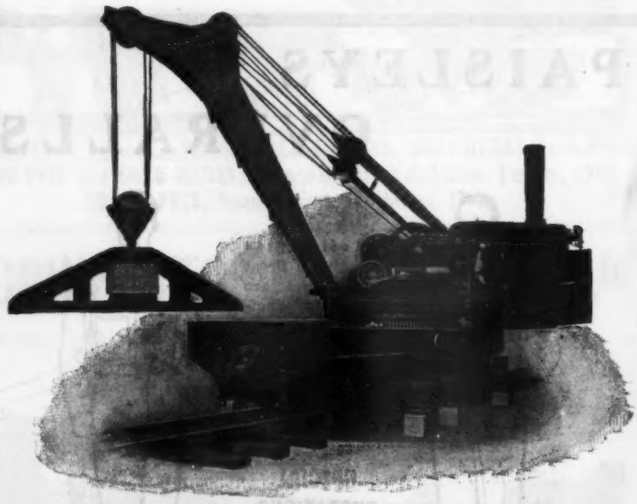
ELECTRO-METALS, LTD.,

HEAD OFFICE:
56, Kingsway,
London, W.C. 2.
(Holborn 6430).

MANCHESTER:
R. MILLETT,
36, Cross Street.
(City 7772).

NEWCASTLE-ON-TYNE:
J. R. STRAKER-WILSON,
3, St. Nicholas Buildings.
(Central 2749).

8792



THREE SUPPLIED TO THE INDIA OFFICE.

20 TONS
STEAM BREAKDOWN CRANE
1 METRE GAUGE. 8430

JOSEPH BOOTH & BROS., LTD.
RODLEY, LEEDS.
London Office: CAXTON HOUSE, WESTMINSTER.

SMOOTH-ON

TRADE-MARK

IRON CEMENTS

Make permanent repairs of steam, water or oil leaks on iron and steel castings, boilers, engines, tanks, etc.

Every Engineer and Foundryman should have a copy of our new 144 page illustrated Instruction Book. It is free.

WALTER P. NOTCUTT, LTD.,
8, White Street, Moorfields, London, E.C.

Large stocks on hand ready for immediate delivery by

LONDON.
Messrs. F. A. PULLEN & CO.,
58, Harleyford Road, Vauxhall, S.E. 11.
BUCK & HICKMAN, Ltd.,
2/4, Whitechapel Road, E.

LIVERPOOL.—Mr. JOHN TAYLOR, 10, Strand St.

MANCHESTER.
THE WALMSLEY ENGINEERS' SUPPLY CO.,
28, King Street West.
A. DAWES & SONS, Ltd., 131, London Road.

HULL.—J. P. MOFFATT, 454½, Anlaby Road.

CARDIFF.—A. E. SMITHSON & CO., West Bute St.

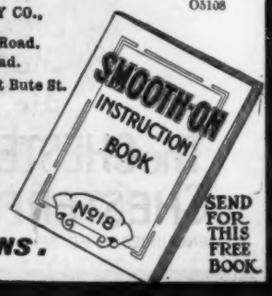
GLASGOW.
ANDREW McLEAN & CO.,
109, Main Street, Bridgeton.

WEST BROMWICH.
THE FORDATH ENGINEERING CO., LTD.,
Hamblet Works.

BIRMINGHAM.
Messrs. CLARK & HOWARD,
177, Corporation Street.

BEWARE OF IMITATIONS.

O5108



SEND FOR THIS FREE BOOK.

WINN'S SCREWING MACHINES

FOR TUBES OR BOLTS

T660

THE ILLUSTRATION SHOWS AN ELECTRICALLY DRIVEN SCREWING MACHINE FOR TUBES OR BOLTS.

THE IDEAL MACHINE FOR SHIPYARDS AND ERECTING JOBS, BEING PORTABLE AND HANDY. MADE IN SIZES UP TO 4 IN. TUBES AND 2 IN. BOLTS.

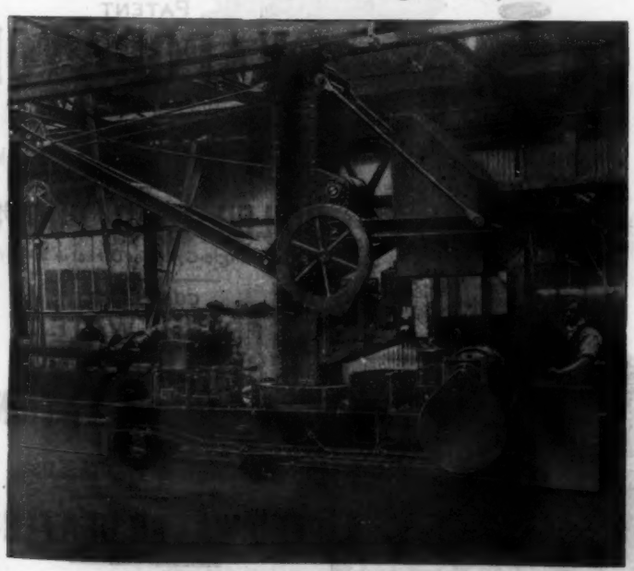
HIGH SPEED CUTTING-OFF MACHINES.
VERTICAL MULTI-SPINDLE TAPPERS.

CHARLES WINN & CO. LTD.

GRANVILLE PLACE, BIRMINGHAM.

EAST FERRY ROAD ENGINEERING WORKS CO., LTD.

Hydraulic Cranes and Coal Hoists, Hydraulic Presses of all descriptions
Patent Pneumatic Grain Elevating Machinery.



3 TONS ELECTRIC MONO-RAIL CRANE. RADIUS OF JIB 12 FEET. LIFT 9 FEET.

1978

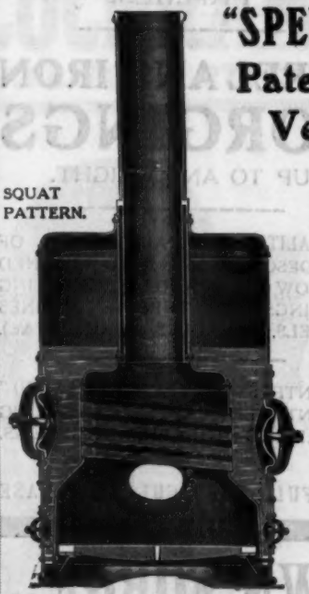
GENERAL ENGINEERS AND IRONFOUNDERS,

——— **Estimates given for Repairs.** ———

Telegrams: HYDROSTATIC, 'PHONE, LONDON. **MILLWALL, LONDON, E.**

"SPENCER-HOPWOOD" Patent Water-Tube Vertical Boilers

SQUAT PATTERN.



For Railway Breakdown and other Cranes, and for all cases where headroom is limited.

Standard Squat, Marine and Launch Patterns.

Adopted by all the principal Crane Makers for Steam Breakdown Cranes, and used on most of the British, Colonial, Indian and South American Railways, also by The Admiralty, War Office, &c.

SPENCER-BONECOURT, Ltd.,

Engineers and Boiler Makers.

HEAD OFFICE:
Parliament Mansions,
Victoria St., London, S.W. 1.
Telephone: Victoria 5663.

8420

WORKS:
Hitchin,
Hertfordshire
Telephone: Hitchin 8.

Salmson
AERO ENGINES

(CANTON-UNNE SYSTEM)

Sole Concessionaires for the British Empire:—

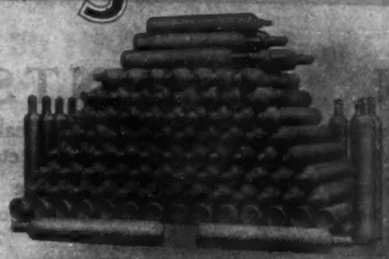
THE DUDBRIDGE IRON WORKS, LTD.,
STROUD,
GLOUCESTERSHIRE.

London Office: 87, VICTORIA STREET, S.W. 1.

5293

ON ADMIRALTY, WAR OFFICE, AND INDIA OFFICE LISTS

Cylinders



Weldless Steel Cylinders
for Carbonic Acid Hydrogen
Oxygen. Ammonia and
other Compressed Gases
Diesel Engine-
Starting Bottles
and
Air Receivers.

The CHESTERFIELD TUBE Co LTD
CHESTERFIELD, ENGLAND.

ENQUIRIES TO BE SENT TO CHESTERFIELD, QUOTING "B E."

TELEGRAMS: FORGE, DUMBARTON

TELEPHONE: No. 56.

EXCEPTIONALLY QUICK DELIVERY GIVEN FOR

FINISHED CRANK SHAFTS, PROPELLER SHAFTS with Continuous Gun-Metal Liners complete, and STERN AND RUDDER FRAMES.

STEEL AND IRON FORGINGS
UP TO ANY WEIGHT.

SPECIALITIES:—REPAIR WORK OF ALL DESCRIPTIONS, ALSO FINISHED HOLLOW CRANK AND LINE SHAFTING FORGINGS FOR TURBINE ENGINES (WHEELS, SPINDLES, DRUMS, &c.).

PATENTEES OF THE "WEDGWOOD" PATENT VERTICAL INTER LOCKING SCARPHED JOINTED RUDDERS.

FOR FULL PARTICULARS PLEASE WRITE:

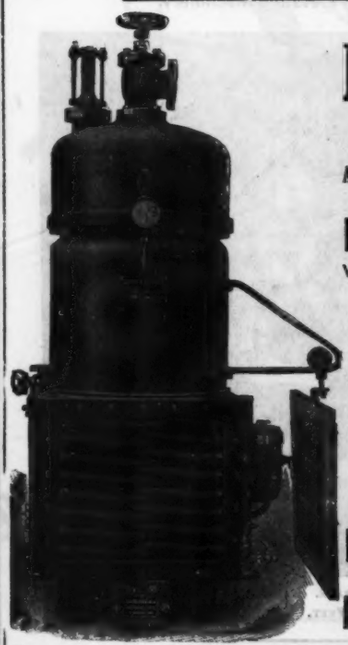
DENNYSTOWN FORGE CO.
DUMBARTON.

8443

ON ADMIRALTY, WAR OFFICE and CROWN AGENT'S LISTS.

LONDON OFFICE: 39, VICTORIA ST., WESTMINSTER, S.W.1.
NEWCASTLE OFFICE: 24, DEAN STREET.
LIVERPOOL OFFICE: 26, AFRICAN HOUSE, BELFAST OFFICE: and 101, BRIDGE END, 6, WATER STREET.

CAIRD & RAYNER,
Admiralty and War Office Contractors.



PATENT
EVAPORATOR
FRESH WATER FEED MAKE-UP APPARATUS.
Approved by Board of Trade for Passenger Ships

BOILER FEED PUMPS.
Vertical Single-Cylinder Direct-Acting type.

COMPLETE
FRESH WATER DISTILLING INSTALLATIONS
(All Sizes)
For LAND or MARINE USE.

FEED WATER HEATERS.

FEED WATER FILTERS.

777, Commercial Road, Limehouse,
LONDON, E.

5093

Tel. Address: VAPORIZE, LONDON. Telephone: No. 210, Eastern.

CRAIG & DONALD, Ld.

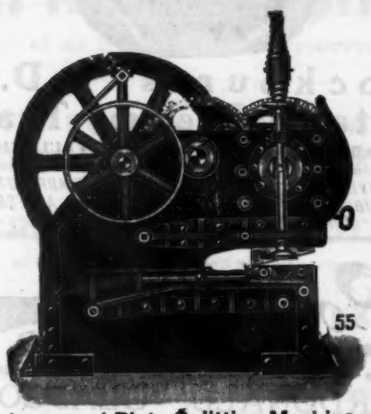
JOHNSTONE, near GLASGOW.

MAKERS OF

MACHINE TOOLS

WITH

PLATE FRAMES



Improved Plate Splitting Machine.

STRUCTURAL STEEL WORK

BRIDGES, ROOF TRUSSES, THEATRE STEELWORK, &c.

An Engineering Shop in Course of Erection. 9049

GEO. SANDS & SON, LTD.

COLWICK - NOTTINGHAM.

ESTABLISHED 1865. Telephone 977 Nottingham.

BACK-GEARED VERTICAL DRILLS

20 in. and 21 in. Sizes.

DELIVERY FROM STOCK.

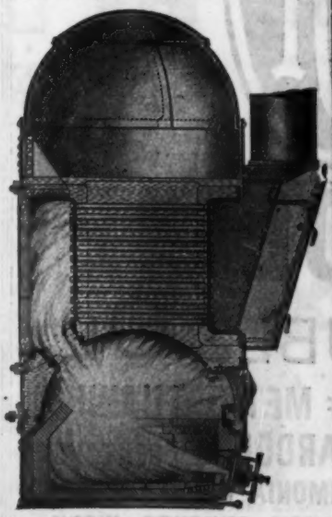
DELIVERY FROM STOCK.

8843

MAYCOCK, CHAPEL STREET, STALYBRIDGE

COCHRAN BOILERS

PATENT VERTICAL MULTITUBULAR



MADE IN STOCK SIZES UP TO 1000 SQ.FT. HEATING SURFACE

ACCESSIBLE ECONOMICAL

WRITE FOR CATALOGUE

LAND, MARINE, WASTE HEAT, ETC

8206

COCHRAN & Co., ANNAN, LTD., ANNAN, SCOTLAND.

Telegrams, 'MULTITUBE, ANNAN' Telephone, No. 2, ANNAN.

BEST BRITISH STEEL

We manufacture the BEST BRIGHT DRAWN STEEL for all purposes. We supply it in HEXAGONS, ROUNDS, SQUARES AND FLATS.

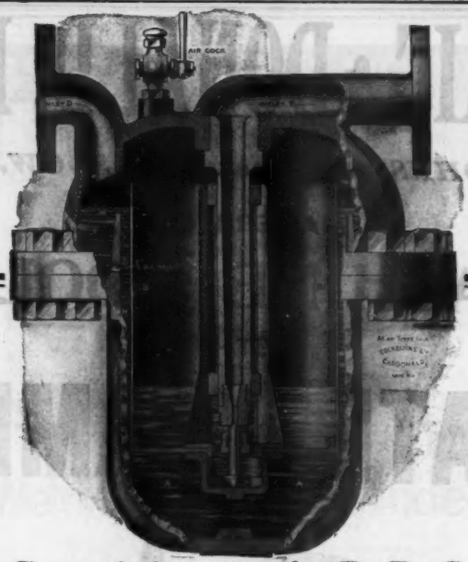
Send us YOUR enquiry TO-DAY!

We are also makers of the BEST STEEL BOLTS, NUTS, WASHERS, SET SCREWS, STUDS, &c.

Let us Quote YOU! 9050

HAMPTON & DEAN,
CLIFTON WORKS - - WEDNESBURY.
Telephone—Darlaston 89. Telegrams—"Clifton, Darlaston."

LONDON OFFICE - 30, ST. MARY AXE, E.C. 3.
Telephone—Avenue 1482. Telegrams—"Busiris, Lsd., London."



Cockburns' R.D.S. Patent Steam Trap.
SUITABLE for MARINE & LAND INSTALLATIONS.

POSITIVE AUTOMATIC ACTION. SHARP CUT-OFF.
NO DRIBBLING. READILY ACCESSIBLE.
FEW AND SIMPLE WORKING PARTS.

Cockburns LIMITED 7844
"The World Renowned Steam Valve Specialists."
CARDONALD, GLASGOW.

ALL BRITISH BOP MANUFACTURE

"LARDOLINE"

THE SOLUBLE OIL

FOR ALL CLASSES OF METAL TURNING AND GRINDING:— LARDOLINE CONTAINS NO RESIN, ALCOHOL, AMMONIA OR OXIDISABLE OILS, AND DOES NOT RUST FINISHED WORK.

BRITISH OIL PRODUCTS CO., Ltd., 9400
TOWNMILL ROAD, ...
DENNISTOUN, ... GLASGOW.

TWO AND THREE STAGE COMPRESSORS

FOR COMPRESSION AND LIQUEFACTION OF — GASES. —

CO_2 REFRIGERATORS.

CO_2 ICE MAKING MACHINES.

Telegrams: SEAGERS, DARTFORD.
National Telephone 26, DARTFORD.

SEAGERS, Ld.
DARTFORD. 9300

WORTHINGTON-SIMPSON,
LIMITED.

Head Office: Queen's House, Kingsway, W.C. 2.

WORKS: NEWARK-ON-TRENT,
and 101, Grosvenor Road, London, S.W. 1.

Telephones:—
8048, 8049, 8050, Holborn.

Telegrams and Cables:—
AQUOSITY, LONDON;
PUMPING, WESTCENT, LONDON.

Manufacturers of High-class

PUMPING MACHINERY

of all types and for every service.

COMPLETE PLANTS FOR WATERWORKS, SEWAGE WORKS AND MINES.

PERIODICAL INSPECTIONS
of Machinery undertaken and Reports given.

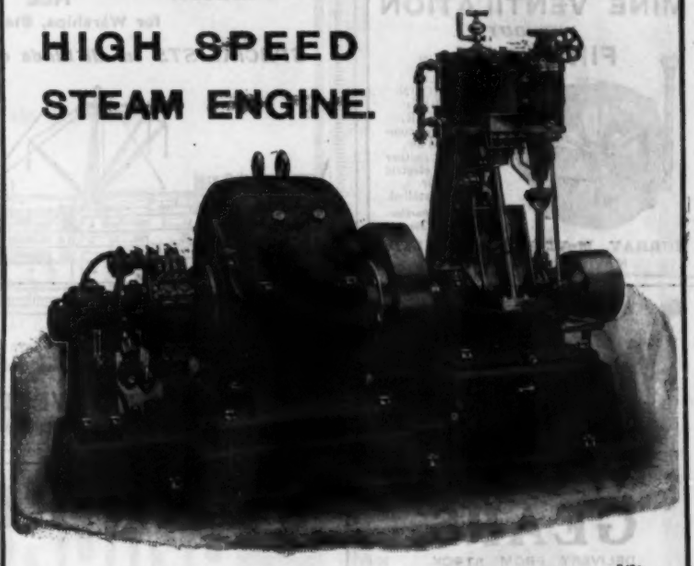
REPAIRS OF ALL KINDS EXECUTED.

5608

FIRE SUPPLIES of all descriptions.

THE
READER

HIGH SPEED
STEAM ENGINE.

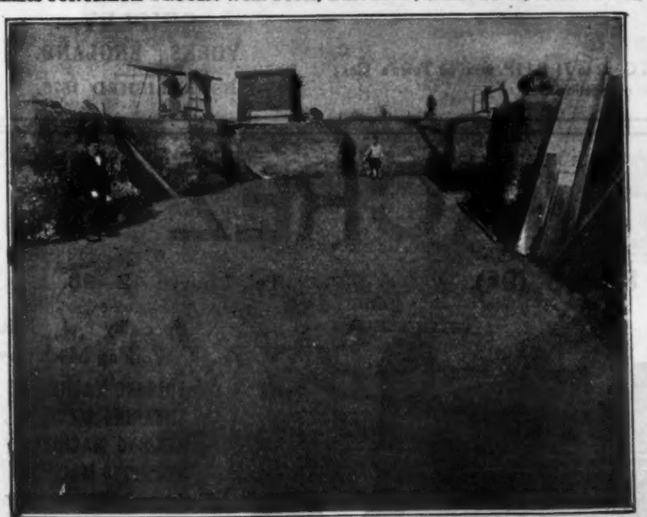


CLASS Z ENGINE. WITH ELECTRIC GENERATOR. 5480
Specially Designed for Use on Board Ship. All Sizes to 75 B.H.P.

E. READER & SONS, LTD., NOTTINGHAM.
Telegrams "Readers, Nottingham." Telephone 414.

"IRONITE" ENTIRELY BRITISH
REGISTERED TRADE MARK.

BRAND CEMENT FOR FLOORING
Makes CONCRETE FLOORS Wear Proof, Dust Proof, Water Proof, Grease Proof.



Underground Heating Chamber 10ft. below ground rendered tight with "Ironite" on Floor and Walls

Also "IRONITE" Brand CEMENT for WATERPROOFING. 8505

CONTRACTORS TO WAR OFFICE, ADMIRALTY, AND OTHER GOVERNMENT DEPARTMENTS.

THE IRONITE COMPANY, LIMITED,
(Managers—S. THORNELY MOTT & VINES, Ltd.),
11, Old Queen Street, Westminster, LONDON, S.W. 1.
Telephone—No. 5618, VICTORIA. Telegrams—THORMOTVIN, VIC., LONDON.

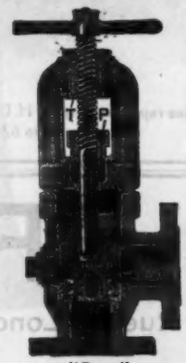
SOLE INDIAN AGENTS—HEATLY & GRESHAM, Ltd., Calcutta, 6, Waterloo St.; Bombay, 204, Hornby Rd.; Madras and Lahore. SOLE AGENT FOR THE DUTCH EAST INDIES—N. V. TECHNISCH BUREAU "SOENDA." Head Office: Bandoeng. Branch Establishments: Batavia, Soerabaya, Malang, Cheribon and Medan.

OIL & GREASE CUPS - INJECTORS - EJECTORS

VALVES AMERICA'S BEST LUNKENHEIMER QUALITY SINCE 1862 LUBRICATORS

LUNKENHEIMER

Straightway & "Duro" BLOW-OFF VALVES.



"Duro" Blow-off Valve.

Insure long and continuous service.

The self-cleansing seat aids in preventing the accumulation of sediment on the seating faces, thereby insuring a minimum cost of upkeep. Obtainable with double-faced reversible disc, permitting the replacement of the old metal in the disc faces when worn.

The "Duro"—Iron Body Bronze Mounted—is furnished in sizes 1¼ to 2½ in. inclusive, for 250 lb. working steam pressure.

The "Renewo" Bronze Straightway with nickel seat and disc is obtainable in sizes ¾ to 2½ in., inclusive, for 200 and 300 lb. pressures, and the Iron Body Straightway Blow-off Pattern is procurable in sizes 1¼ to 2½ in. for 125 and 250 lb. pressures.

"Renewo" Straightway Blow-off Valves. 5669

Write for Catalogue or address enquiries to:

The Lunken Co., Ltd.,
35, Great Dover Street LONDON, S.E.
Factories: Cincinnati, Ohio, U.S.A.
Telegraphic Addresses: "LUNKEN, LONDON." "LUNKEN, CINCINNATI."

COCKS - AUTOMOTIVE ACCESSORIES

OIL PUMPS - WHISTLES - WATER COLUMNS & GAUGES

HAMWORTHY

OIL ENGINES,
PUMPS and AIR COMPRESSORS.
THE HAMWORTHY ENGINEERING CO., LTD
78, VICTORIA STREET, LONDON. 8436

MINE VENTILATION
WITHOUT
FIRE RISK 8799

TYPHOON TURBINE BLOWER, driven by compressed air, requires neither belts nor electric motor. Easily installed.
Prices and Particulars from Makers—
MURRAY, McVINNIE & CO., LTD.,
MAVISBANK, GLASGOW.

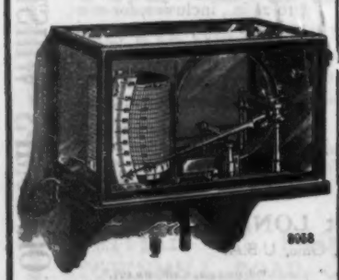
Wallwork

HIGH EFFICIENCY
WORM GEARS
DELIVERY FROM STOCK. 8840
HENRY WALLWORK & CO., LTD. MANCHESTER.

SCRAP METALS

Send Your Enquiries to
F. W. HARRIS,
(BIRMINGHAM) LTD.,
132, HURST STREET,
BIRMINGHAM.
Largest Dealers in the Provinces
Authorised by Ministry of Munitions
Established 1881.
7918
IMPORTERS and EXPORTERS of SCRAP METALS.

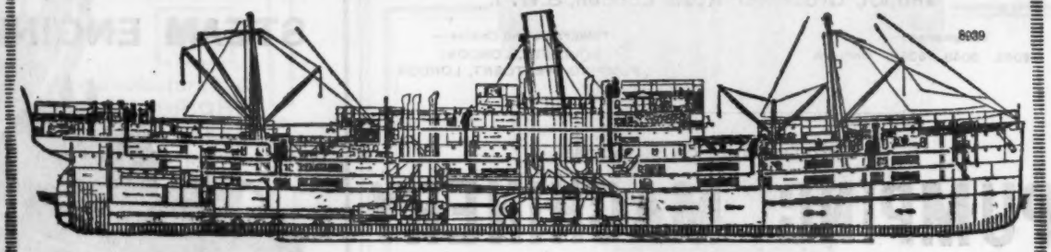
BUDENBERG GAUGE Co. LTD (Late Schaffer & Budenberg Ltd.) BROADHEATH Nr. MANCHESTER.
BRANCHES: LONDON & GLASGOW.
Makers of
PRESSURE GAUGES,
Tachometers, Counters,
Dial-Thermometers,
Test Pumps, &c.



8068
SELF-RECORDING INSTRUMENTS
FOR
PRESSURE, TEMPERATURE and SPEED.

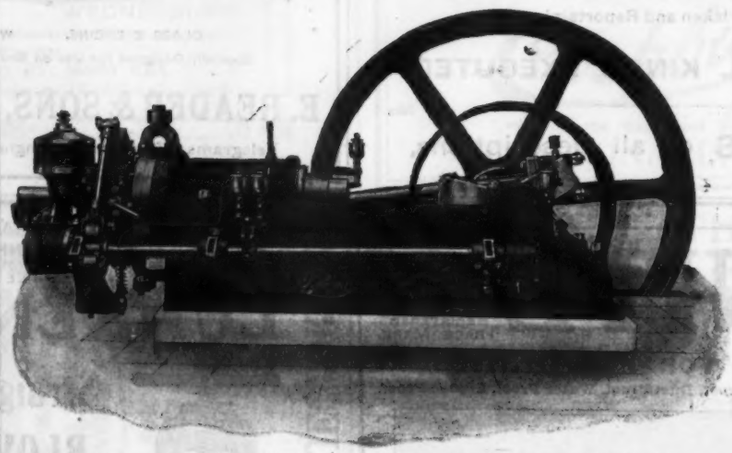
THERMOTANKS

THE THERMOTANK CO., GLASGOW, SCOTLAND.
Telegrams: "THERMOTANK, GLASGOW."
MANUFACTURERS OF
ALL KINDS OF VENTILATING MACHINERY
Telephone: DOUGLAS No. 2324.
for Warships, Steamers Public Buildings, Hotels, Hospitals, Workshops, &c.
SPECIALISTS in all kinds of WARMING and COOLING PROBLEMS on LAND and SEA.



8039
Heating and Cooling Installations have been fitted on board many of the latest Warships for the British, Russian, French, Italian, Spanish, Japanese, Brazilian and Argentine Navies; also on most of the leading Passenger Steamers in the world.
Head Office: 55, WEST REGENT STREET, GLASGOW. Works: Govan.

JOHN ROBSON (Shipley) LTD.



Gas Engine representing types H.D.G. to H.H.G. 32 to 71 B.HP. max. on Town's Gas; 28 to 62 B.HP. max. on Suction Gas.

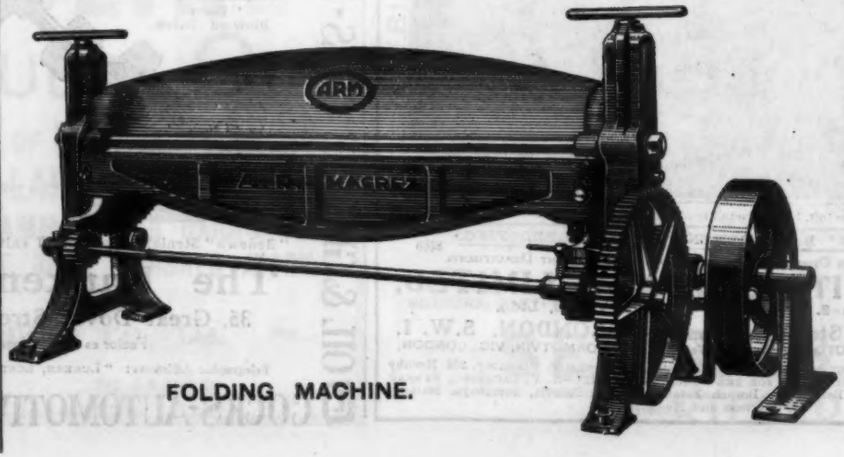
Sole Makers of the
"ROBSON"
Gas Engines,
Suction Gas Plants,
Oil Engines.
(Ordinary and Semi-Diesel types.)

Telegrams: "ROBSONS, SHIPLEY."
Code: A.B.C., 5th Edition.
LONDON OFFICE—
6, Broad Street Place,
London, E.C. 2.

ALEXANDRA WORKS,
SHIPLEY,
YORKS., ENGLAND.
7903
ESTABLISHED 1870.

AR. MACREZ

34 Rue de Londres, PARIS (9E). Tel. Louvre 42—96.



FOLDING MACHINE.

Speciality of Metal Working Machinery
FOLDING MACHINES.
SHEARING MACHINES.
BENDING MACHINES.
STAMPING MACHINES.

Machine-tools for maximum size ½-in.
Quick delivery
Guaranteed make.

Send us your enquiries, you will receive prompt attention.

8616

BRIGHT STEEL & IRON SQUARE HEADS.

Immediate delivery *and low prices.*

KIRBY BANKS SCREW CO., LTD.,

Bolt, Nut & Screw Manufacturers,

MEADOW LANE, LEEDS.

Telegraphic Address—"HEXAGON, LEEDS." Telephone—20104 and 20105.

ECONOMICAL GRINDING.

EMERY WHEELS AND GRINDING MACHINES.

BRITISH MADE.

L. STERNE & CO., LTD.,

THE CROWN IRON WORKS, GLASGOW.

LONDON OFFICE: DONINGTON HOUSE, NORFOLK ST., W.C.

EQUIP your Works NOW with a PERMUTIT WATER SOFTENER

(no chemicals—no sludge)

and dispose of the hard water problem for good.

Write for 1919 Catalogue to—

UNITED WATER SOFTENERS Ld.,

Imperial House, Kingsway,

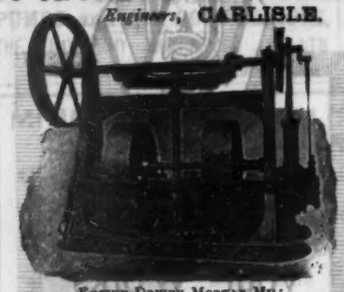
LONDON, W.C. 2.

'Phones: Regent 5270 (4 lines).

'Grams: "Aquadolce, Estrand, London."

PRATCHITT BROS.

Engineers, CARLISLE.



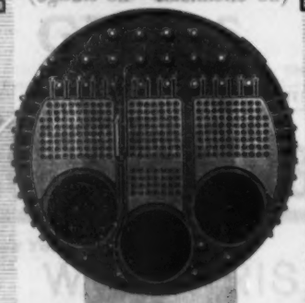
Engine Driven Mortar Mill.

ALSO MAKERS OF— 4187

RAM PUMPS, DISINTEGRATORS

Colliery and Chemical Manure Machinery.

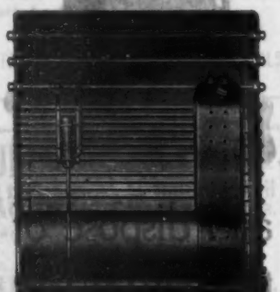
BRUNDRIT PATENT Temperature Balance



THE **AUTOMATIC CIRCULATOR**

For Marine & Land **BOILERS**

Over 4500 Sets in Use



THESE Sectional Views show the simple and practical method of fitting Brundrit's Patent Temperature Balance in Marine Boilers. No drilling or structural alteration is necessary and the boiler can be cleaned with the apparatus in position. . . . . .

Brundrit's Patent Temperature Balance has been adapted by the leading Shipowners and Shipbuilders of the world, and has proved effective in preventing leakages, reducing repair accounts and promoting a thorough circulation.

Over 4,500 sets have been fitted, including all the boilers of the "Aquitania," "Mauretania," and other ocean liners, also large Cargo and Coasting Steamers, Trawlers, Tug Boats, Dredgers, Launches, etc. . . . . .

The Brundrit Temperature Balance has no valves or working parts, and is entirely automatic. . . . *Working models may be seen by arrangement.* . . . . . .

JOSEPH BRUNDRIT

Sole Patentee,

14 Water St. LIVERPOOL.

HARDENED SCREW GAUGES

ALL SIZES. STANDARD & MISCELLANEOUS.

Enquire for List 71.

ACTUAL MANUFACTURERS. 8457

JOHN ACKWORTHIE, LTD., COLESHILL ST., BIRMINGHAM.

THE MOTHERWELL BRIDGE CO. LTD.

MOTHERWELL, N.B.

Telegraphic Address—"BRIDGE." National Telephone No. 40.

BRIDGES, ROOFS, PIERS, TANKS,

DOCK GATES, AND SIMILAR **STRUCTURAL WORK.**

HYDRAULIC PRESSED FLOORING A SPECIALITY.

Machinery and Steels, Ltd., London, E.C.

ENGINEERING MANUFACTURERS AND MERCHANTS.

Telephone No.: Clerkenwell 1927.
Telegraph Address: Acmehel, Bethroad, London.

"Luton House," 64, Great Eastern St., London, E.C. 2.

NEW.

Best known British and Swedish only. Prompt Service Inspections.

GEAR HOBBERS.
16 and 32 in.

PRECISION HIGH PRODUCTION LATHES.
Up to 20 in. centres.

TOOL ROOM LATHES.
Ordinary gap, cone or single pulley drive, Norton Type, gear box, 6, 7, 8, 9, 10 in. centres.

CAPSTAN AND BAR LATHES.
From ⅝ in. up to 3½ in.
Clark's Machine Tool Co.

SLOTTING MACHINES.
3, 4, 6, 10½, 12 in.
Clark's Machine Tool Co.

UNIVERSAL MILLERS.
Latest and most perfect types. Clark's.

PLAIN MILLERS.
Denbigh, Clark's.

PLANING MACHINES.
High Speed only 48 by 20 & 72 by 27 in.

RADIAL DRILLING MACHINES.
32, 40, 42, 48 in.

HORIZONTAL BORING MACHINES.
Up to 5 in. spindle.

SHAPING MACHINES.
(Average stock 30 to 50) 15, 18, 22, 25 in.

S.S. & S.C. LATHES.
High duty gap, 7½ by 8 ft., 9 by 10 ft., 11 by 12 ft., and others.

GARAGE LATHES.
4½ and 7 in. centres.

UNIVERSAL TOOL GRINDERS.
Swedish.

SECOND-HAND.

Sold at cost and below cost. In every case thoroughly good and complete Machines.

VERTICAL MILLERS.
As new, Beckers A. B. No. 1.

GRINDING MACHINES.
B. & Sh. No. 4 (60 in. by 13 in.) Universal.
Meyer & Schmidt Plain 18 in.

SLOTTING MACHINES.
3, 6, 8 in.

PLANING MACHINES.
Various.

SHAPING MACHINES.
All sizes.

COMBINATION TURRET.
Boring and Facing Lathes, 20 in. swing as new, Parkinson's.

TURRET LATHES.
Hexagon - Turret, 8 in. centres, Pollock & McNab.

LATHES.
S.S. & S.C. Gap, 12 in. by 16 ft. and 9½ in. by 8 ft. Straight 9½ in. by 8 ft.

UNIVERSAL MILLING MACHINE.
Garvin.

LARGE BREAK LATHE
As new, 7 ft. swing.

TURRET SLIDES.
Hexagon, new.

CAPSTAN LATHES.
Small size Shapers. Plain Millers.

WOODWORKING MACHINES.

PRECISION WORK, BALL BEARINGS.
Best known Swedish and British only.

PATTERN SHOP SAW BENCHES.
Bench Jointers and Planers.

BAND SAWS.
28, 30, 36 in.

JOINERY MACHINES.
Combined Planers, 15 and 20 in.

THICKNESSERS.
20, 24, 30 in.

JOINTING MACHINES.
Circular Cutterheads, 6, 9, 12, 16, 18, 22 in.

SPINDLE MOULDERS.
1½ and 2 in. Spindles, Single, Double.

CHAIN AND HOLLOW CHISEL.
Mortisers.

TENONING MACHINES.
All Combinations.

SAW MILL MACHINES.
Horizontal Band Mills.
Circular Re-saw.
Band Re-saw.

FOUR CUTTER PLANING MACHINES. 8775

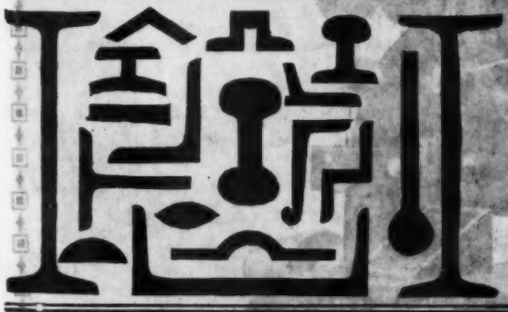
EXPERT ADVICE at your disposal.

P. R. JACKSON & Co. LTD.,

SALFORD ROLLING MILLS
MANCHESTER

OLDEST AND LARGEST MAKERS OF
WHEELS WITH STRAIGHT
STAGGERED OR DOUBLE HELICAL TEETH
MACHINE MOULDED OR MACHINE CUT

HENDERSON & GLASS, LIVERPOOL.



Extensive **STOCKS** of all description and Sections of
MALLEABLE IRON AND STEEL
Including all sizes, Round, Square and Flat Bars, Flitch Plates, Tees, Angles, &c. 8019

Rolled Girders & Joints, 3 in. to 20 in. deep
COMPOSITE GIRDERS MADE TO SPECIFICATION.
PLAIN AND CHEQUERED PLATES.
Boiler and Tank Plates in Iron or Siemens-Martin Steel, all sizes.
QUOTATIONS AND SECTION SHEETS ON APPLICATION.
SHIPMENT ORDERS PROMPTLY EXECUTED. CORRESPONDENCE SOLICITED.

D.A.

"Pure Acetylene in Cylinders."

FOR Welding Metals of all Classes & Sections ¶ Efficient High Pressure Acetylene Equipment for Manufacturing or Repairing.

Apply for list and particulars of complete plant and local service of regular gas supplies:
ALLEN-LIVERSIDGE LTD.,
with which are amalgamated
IMPERIAL LIGHT Ltd.,
and
8972 The DISSOLVED ACETYLENE Co., Ltd.,
106, Victoria Street, S.W. 1.

J. & E. HALL, LTD.,

Makers of CO_2 and NH_3
Refrigerating Machines
—and—
Hallford Motor Vehicles
19, ST. SWITHIN'S LANE, LONDON, E.C. 4.
4, Inner Temple, Dale St., Liverpool,
and DARTFORD, KENT. 8816

REFRIGERATING
MACHINERY
COLD STORAGE & ICE MAKING PLANT
H. J. WEST & CO., Ltd.
72-74 Grays Inn Rd., London, W.C.1

STAMPINGS

ANY WEIGHT, 8127
IN ANY STEEL.
FOR ALL PURPOSES.
HEAVY STAMPINGS LTD.,
MIDDLESBROUGH.
TELEGRAMS—STAMPINGS. TELEPHONE—[illegible]
LONDON OFFICE: 11, Southwark Street, S.E.1.
TELEPHONE—Hop. 8217 (3 lines)

OXY-ACETYLENE

WELDING
AND
CUTTING PLANT
MANUFACTURERS.
COMPLETE EQUIPMENTS.

4004
McGOWAN, WILD & CO.,
Lower Hurst Street,
BIRMINGHAM.
Tel.—[illegible], MIDLAND. Teleg.—Logic, Birm.

OXY-ACETYLENE

WELDING & CUTTING.

The latest and best type of Plant for this process as installed by the leading Shipbuilding and Engineering firms, also H.M. Dockyards is made by

THE ACETYLENE CORPORATION LTD

49, VICTORIA ST., WESTMINSTER

Write for Catalogue of Plant, Blowpipes, Welding Sundries, and price of finest

CARBIDE

Also for Particulars of the new

FLARELIGHTS
AND
HANDLAMPS.

HINDLEY
FRICTION HOISTS
fix anywhere and hoist anything except passenger lifts. Sizes: 3 to 20 cwt. Belt or motor driven. Write
E. S. HINDLEY & SONS
Works - - - Bourton, Dorset.
11, Queen Victoria St., London, E.C.4.
Phone - - - 6004 City.

W. G. BAGNALL, LTD.
STAFFORD.
BUILDERS OF LOCOMOTIVES
Weighing from 3 to 90 tons, for any gauge of Highest-Class Workmanship and Materials.
MAKERS OF
Tipping Trucks, Steam Crane Wagons, Turntables, Switches, &c.
See Illustrated Advert., page 24, Dec. 10.

WATER SOFTENERS
AND OIL
ELIMINATORS
FOR
BOILER
FEED
WATER
8004
HARRIS-ANDERSON
The Harris Patent Feed Water Filter (1910) LIMITED.
94, GRAINGER ST. WEST, NEWCASTLE-ON-TYNE.
T.A.: Wheatsheaf, Newcastle-on-Tyne. Tel.: 3230, Central.
62, VICTORIA STREET, LONDON, S.W.
T.A.: Wheatsheaf, London. Tel.: 876, Westminster.

CLAYTON SON & Co.
LIMITED
WORKS
LEEDS
TELEGRAMS
GAS, LEEDS
LONDON OFFICE
S. VICTORIA ST.
S.W.1

VERTICAL BOILERS
LARGE STOCK READY FOR IMMEDIATE DELIVERY

AERIAL ROPEWAYS.

THE BRITISH ROPEWAY ENGINEERING COMPANY, LIMITED,
7, Mincing Lane, LONDON, E.C. 3.
TELEPHONE—CENTRAL 11250. 6017

ALFRED HERBERT LTD. COVENTRY.

No. 0 VERTICAL MILLING MACHINE, capacity 62 in. by 38 in. by 28½ in.

ONE OF THE MOST USEFUL GENERAL-PURPOSE TOOLS IN THE SHOP.

THE Vertical Milling Machine is one of the most useful general-purpose tools in the shop.

Whilst it will do a great deal of work more economically than any other type of machine, it will perform certain operations for which no other tool can be used.

Most of its work is done without the aid of special tackle, jigs or fixtures, standard clamping arrangements being all that are necessary for securing the work.

In the majority of shops the wide range of work dealt with and the varying nature of the operations performed, call for a machine of large capacity, ample belt power, great rigidity, wide range of speeds and feeds, coupled with ease of control.

The machine illustrated combines these desirable features to an unusual degree. We use it in our own works and know its advantages.

We are always ready to advise on the application of this machine to any specific work, to quote for outfits of cutters, and to give guarantees of production.

DELIVERY FROM STOCK. 0 d 2200

Telephone: No. 286 Smethwick (4 Lines).
Telegraphic Address: "Carriage," Smethwick, Birmingham.

Grand Prix,
Buenos Ayres Exhibition, 1910.

THE BIRMINGHAM RAILWAY CARRIAGE AND WAGON CO., LTD.,

FOR HOME SMETHWICK. AND ABROAD.

MANUFACTURERS OF

RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION, INCLUDING ALL-STEEL CARRIAGES.

PRESSED STEEL UNDERFRAMES, BODIES AND BOGIES.

MAKERS OF RAILWAY WHEELS AND AXLES, IRONWORK, AXLE BOXES, CASTINGS, &c.

Sole Manufacturers of Dean & Churchward's Patent "Eitherside" Brake, and Marillier's Patent "Instanter" Coupling.

WELLS' "LIGHTNING"

LIME AND COLOUR WASHER.

Wallwork and Wells' Patents.

OVER 7000 SOLD.

A GREAT SAVING OF TIME, LABOUR, AND MONEY.

LIME, WHITING, or COLD WATER PAINTS

Applied at a speed of from 10 to 20 square yards per minute, in a manner superior to brushwork. Used with the machine on rough surfaces is equal to two applied with brushes.

Complies with the Factory Act requirements.

WELLS'

Waste Oil Filters.

Fitted with Patent "Sight Feed" System.

OVER 23,000 SOLD.

Invaluable to ALL Users of Machinery, Steam, Oil, or Gas Engines.

Supplied to the Principal Governments, Electric Light Installations, Corporations, Water Companies, Engineers, Munition Works, Garages, &c.

MONEY SAVED TO ANY USERS OF MACHINERY.

Pay first cost in a short time, as Dirted Oil which has hitherto been thrown away, can be filtered and used again and again.

Write for Samples of Work done by the Filter

LARGEN SIZES MADE TO ORDER.

THE "WELLS HEATER."

(Wallwork & Wells' Patents.)

TYRE EXPANDING, BENDING, STRAIGHTENING, SETTING, SHRINKING, &c.

SMALL PLANTS FOR LIGHT WORK.

A. C. Wells & Co. 122, Midland Rd. London W. FANCHAM, N.W. 1.

Works: Cornerfield Street, MANCHESTER.

DEPENDABLE

If your plant loads are fragile as well as heavy, one case dropped by careless handling might cost more than a whole year's upkeep of a

Shepard Electric Hoist

The certainty of its motion, the precision with which its speed can be controlled, the flexibility of such a method of handling material, make a "Shepard" the safest way to move any heavy load.

And the unit construction of a "Shepard" maintains such thorough lubrication, gives such trouble-free service, that it becomes at the same time the most economical as well as the most dependable hoist.

There is a specialized "Shepard" which exactly fits your plant use. Tell our engineers your requirements and they will gladly advise. Look over our handbook, too. A copy is yours for the asking.

It will facilitate matters, if, when writing, you will give us the following information: Electric Current available; Direct or Alternating (if alternating give voltage, phase, periods); heaviest load to be carried; distance load is to be carried; kind and quantity of material to be handled; and a sketch of your plant or the layout you have in mind.

SHEPARD
Electric Crane & Hoist Co.,
General Offices and Works:
Montour Falls,
New York, U.S.A.
London, England. Melbourne, Australia.

SHEPARD
ELECTRIC CRANES & HOISTS

HANDRAIL STANCHIONS.

EDWIN RICHARDS & SONS, Ltd.,
Portway Works - - WEDNESBURY.

DON'T MISS WRITING Q3 FOR FREE SAMPLES.

"METALIN" IRON & STEEL CEMENT For BLOW HOLES &c

SOLE MANUFACTURERS
W.W. HILL SON & WALLACE LTD
BROUGHTON
Established 1840 MANCHESTER

BOLTS & NUTS

USUAL STOCK 1000 TONS

SPECIALITY
FACED & BRIGHT NUTS
LISTS ON APPLICATION

JAMES WILEY & SONS LTD DARLASTON

BRIGHT DRAWN STEEL BARS.

SPUR & BEVEL WHEELS.
CAST IRON, BRONZE & STEEL.
CAST & MACHINE CUT TEETH.

GEAR-WHEELS.

POWER TRANSMISSION.
QUICK DELIVERY.

JOHN TICKLE & CO., LTD.,
PROVIDENCE WORKS, WEST BROMWICH.

HENRY WOOD & CO., Ltd.
SALTNEY, Near CHESTER.

CHAIN AND ANCHOR MANUFACTURERS,
Works adapted to make up to the LARGEST SIZES.
LARGE MOORINGS A SPECIALITY.
BATTLESHIPS' CABLES and GEAR.

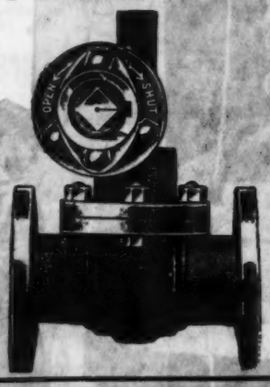
Forgings, Crane Chain, Chain Slings, and all kinds of ANCHORS, MOORING and CABLE GEAR.

WOOD'S "VIKING" STOCKLESS ANCHOR.

Standing Contractors to the British Admiralty, Trinity House and Public Bodies, and Contractors to all FOREIGN GOVERNMENTS.

ON ADMIRALTY AND WAR OFFICE LISTS.

PEGLER BROS. & CO. (Glasgow), LTD.



Registered Office:
54, BROWN STREET.
Works:
BRIDGETON SMELTING WORKS, FORDNEUK STREET,
GLASGOW.

BRASS & IRONFOUNDERS.
High-class Engine & Boiler Fittings.
METAL ALLOY MANUFACTURERS.
All Classes of Non-Ferrous Ingots.

TELE.: "GUNMETAL." 'PHONE: 2340 CENTRAL.

MACHINE CUT WHEELS.

WORM AND SPUR REDUCING GEARS.

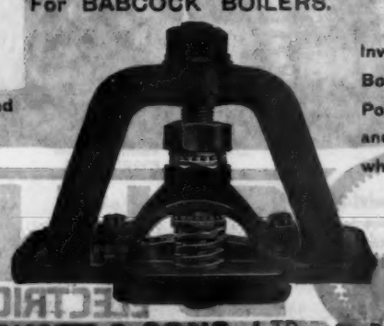
The REID GEAR CO.,
LINWOOD,
near PAISLEY.

SIMPLEX HEADER FACER
For BABCOCK BOILERS.

Makes a True Clean Face.

Is Quickly Fixed and Easily Worked.

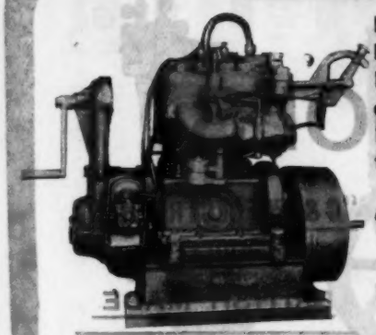
Free Wheel Ratchet Spanner supplied with each tool.



Invaluable on Board Ship, Power Stations, and Factories where Babcock and Wilcox Boilers are used.

W. CROCKATT & SONS, LTD 64, DARNLEY STREET, GLASGOW.

MACLAREN BROTHERS, LTD.,
DUMBARTON.



Makers of Petrol and Paraffin Engines for Marine, Electric Light, Pumping and all kinds of Stationary Work. Complete Marine Sets as supplied to the Admiralty and War Office.

Contractors to Admiralty and War Office.

GLASGOW OFFICE:
24, ST. VINCENT PLACE.
Tel. 5065 Central.

Works: SANDPOINT, DUMBARTON. 170 Dumbarton.

For
CRATEWOOD
and all
ENGINEERING TIMBER
REQUIREMENTS.

G. R. CAWOOD & CO.
English and Foreign Timber Merchants,
4, South Parade, - - - - LEEDS.

Listen!

We can do WORK for you at our Factory

Large or Small Contracts for SMALL ENGINEERING and INSTRUMENT Work.
Components or Complete Units.
SMALL BRASS AND ALUMINIUM CASTINGS.

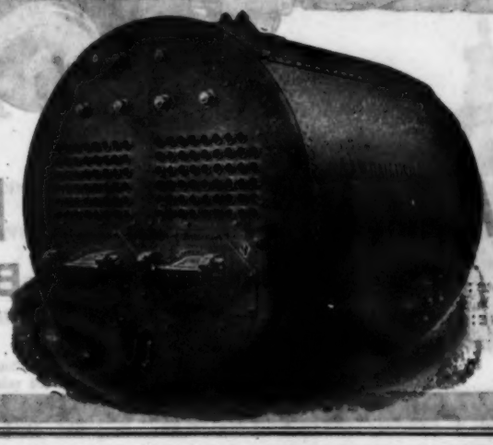
Apply DEPT. A.

HEATH & CO LTD
New Eltham
LONDON, S.E.9

All kinds of Experimental Work in Non-Ferrous Metals.
HARDWOOD INSTRUMENT CASES (polished or unpolished), including brass fittings if required.
8152

TELEGRAMS—*Evaporate, Pollokshaws.* Codes—A B C, 5th Edition.

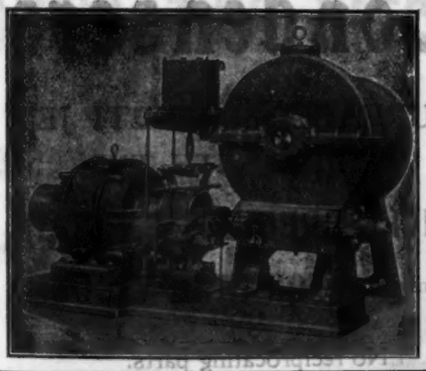
A. & W. DALGLISH.



WEST OF SCOTLAND BOILER WORKS,
Pollokshaws,
GLASGOW.

MARINE, DRYBACK, LOCOMOTIVE and MULTITUBULAR BOILERS.
7461
ALL SIZES.
MADE BY THE MOST IMPROVED MACHINERY.

LIFTS.
A. & P. STEVEN,
181, St. James' Rd
GLASGOW.



London Office:
10, CHARLES STREET, BLACKFRIARS, S.E. 1.

Manchester Office
12, CHARLES STREET.
8581

Birmingham:
HARRY ASTBURY,
DAIMLER HOUSE
PARADISE STREET

OUR SPECIALITY.
VALVES
FOR ALL STEAM PURPOSES
A. COCKBURN & Co.
THISTLE VALVE WORKS, GATESIDE STREET,
GLASGOW.

CHURCHILL GRINDERS
Plain & Universal, Tool and Cutter, Internal Cylinder, Surface Crankshaft, Cam, Vertical and Plane Surface.
Made by the CHURCHILL MACHINE TOOL Co.
Sold by
CHARLES CHURCHILL & Co. LTD
& Branches
8984
C.G.13

WHY WASTE TIME AND MONEY ON FITTING PINS AND CASTLE NUTS?

WHEN GROVER (Spring Lock Nut) WASHERS SERVE THE SAME PURPOSE at HALF THE COST.
8961

BUT BEWARE OF IMITATIONS.
THE GENUINE ARTICLE IS MANUFACTURED ONLY BY
GROVER & CO., LTD.,
Britannia Engineering Works, CARPENTERS ROAD, STRATFORD, LONDON, E. 15.
Telegraphic Address: "ADOPTED, STRAT, LONDON." Telephones: STRATFORD 984 & 985.

C & I

ELECTRIC PORTABLE TOOLS.

DRILLS & GRINDERS.

SEND FOR CATALOGUES.

"C & I" ELECTRIC HAND DRILL.

BRITISH MADE

TYPE.	SIZE.	Max. Cap.	Morse Taper.	Length of Feed.
D.C.	0	½"	No. 1	2"
D.C.	1	¾"	No. 2	2"
D.C.	2	1"	No. 3	2½"

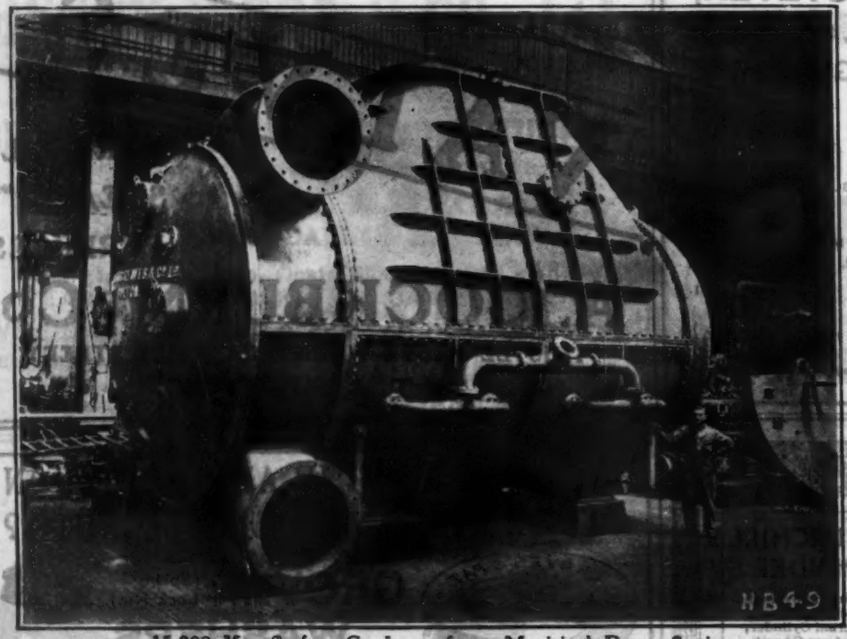
STANDARD VOLTAGES

FROM STOCK.

CAMPBELL & ISHERWOOD, LTD.

TELEGRAMS: "PRESSURE."
TELEPHONE: 1474 BOOTLE.

BOOTLE, NR. LIVERPOOL.



15,000 Kw. Surface Condenser for a Municipal Power Station.

Condensers

SURFACE and MULTI JET
FITTED WITH THE
HICKS-BREGUET EJECTAIR
(PATENTED) FOR HIGH VACUUM.

No reciprocating parts.
Guaranteed reliability.
Minimum upkeep charges.

Vacuum unaffected by 20% fall in steam pressure. Patent Automatic Control ensures vacuum stability. The plant with lowest operating power.

HICK, HARGREAVES & CO., LTD.

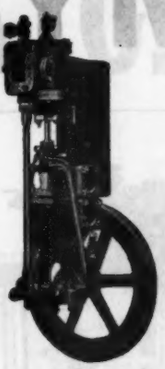
BOLTON, ENGLAND. ESTABLISHED 1832.

Telegraphic Address: "HICK, BOLTON." "UMSHAWAPO, FLEET, LONDON." Telephone: Bolton 1573-4. Nos. London—8668 Central

LONDON OFFICE: 90, Temple Chambers, Temple Avenue, London, E.C. 4.

Telegraphic Codes:—A.B.C. Fifth Edition; A 1 (1908), Western Union (Universal Edition), Lieber's Standard.

THE MANCHESTER DONKEY OR WALL PUMP



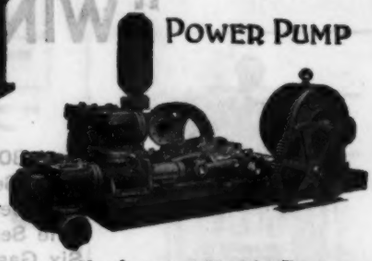
Single Acting

Double Acting

FRANK PEARN & Co LTD
MANCHESTER. S.E.

THE PEARN PUMP

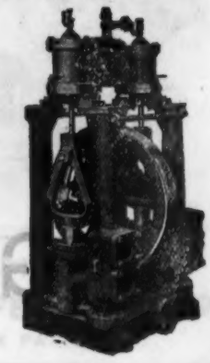
POWER PUMP



Horizontal Treble Ram.

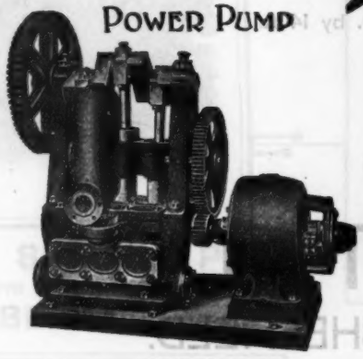
PEARN'S CAMERON TYPE PUMP

Single Ram.



Double Ram.

POWER PUMP



Vertical Treble Ram.

Telephone
No 2289. Central.

Telegrams
"PUMPS" MANCHESTER

Agents for Straits Settlements and
The Federated Malay States O 8481
THE BORNEO CO., Ltd., Singapore.

LONDON: 49, Queen Victoria St., E.C. GLASGOW: P. & W. MACLELLAN, Ltd., 129, Trongate. NEWCASTLE-ON-TYNE: LINDSAY & WARD, 90, Pilgrim Street.

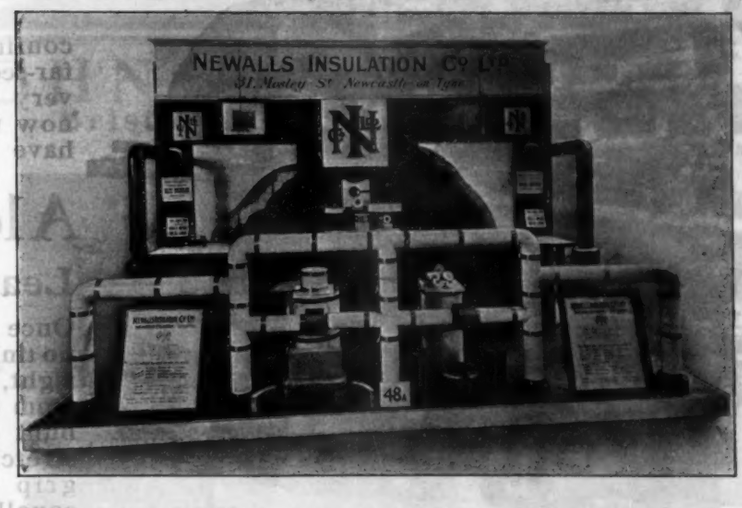
INSULATING SPECIALISTS, ENGINEERS AND CONTRACTORS

NEWALLS
INSULATION Co. LTD.

HEAD OFFICE:—
31, MOSLEY STREET,
NEWCASTLE-ON-TYNE.

Telegrams:—
"NEWALLS"
NEWCASTLE-ON-TYNE.

Telephones:—
CENTRAL, 3435.



NEWALLS
INSULATION Co. LTD.

BRANCH OFFICES AT:—
LONDON, BIRMINGHAM,
MANCHESTER, LEEDS,
GLASGOW, HULL.

Agencies all over the World.

Our Stand at the Shipping, Engineering and Machinery Exhibition, Olympia, London, 1919,
showing some of our specialities,

FOR THE INSULATION OF 7918

Steam Pipes.	Cold Stores.	Furnaces.	Locomotives.	Ships' Engine Room and Funnel Casings.
Boilers.	Ice Plants.	Ovens.	Passenger Carriages.	Ships' Refrigerated Spaces.
Flanges.	Brine Pipes	Stoves.	Refrigerated Waggons.	Ships' Bulkheads.

FUEL ECONOMY.

"WINCOTT" FURNACES

FOR ALL PURPOSES.

CONTRACTS IN PROGRESS.

Two 80-ton Open Hearth Steel Melting Furnaces.
Four Semi-Gas Mill Re-heating Furnaces.
One Semi-Gas Continuous Billet Re-heating Furnace, 27 ft. long.
One Semi-Gas Continuous Ingot Re-heating Furnace.
Six Gas Fired Hammer and Press Forging Furnaces.
Four Gas Fired Rotary Annealing Furnaces.
Two Coal Fired Sheet Annealing Furnaces.
One Gas Fired Bogie Sheet Annealing Furnace, 126 ft. long.
Six Combined Bar and Sheet Mill Furnaces.
One Gas Fired Bogie Annealing Furnace, 50 ft. by 14 ft.
Four Semi-Gas Drop Stamp Furnaces.
Three Semi-Gas Plate Furnaces.
Two Semi-Gas Plate Furnaces.
Four Gas Producers.
Four Chimneys, &c.

SEND YOUR ENQUIRIES TO—

G. P. WINCOTT, Ltd.,

180, ATTERCLIFFE ROAD, SHEFFIELD.

7231

Illustrating an operation in the manufacture of Alexander belting—the leather is stretched and left to season in the special cramp. This ensures a permanent stretch. Can our representative demonstrate its other merits to your Works Department?

Perfectly Stretched & Seasoned Belting

confirms its choice by far-seeing buyers, in a very marked manner, now that labour charges have risen so largely.

Alexander Leather Belting

Once installed, requires no tinkering with. It runs right, gripping the pulley from edge to edge. It is built on the five piece stretch principle and will grip crowned pulleys equally as well as flat.

8530

Buck & Hickman, Limited

2 & 4, WHITECHAPEL ROAD, LONDON, E.C.1.

B&H TOOLS & SERVICE

A. G. MUMFORD, Ltd., Colchester.

Engineers,

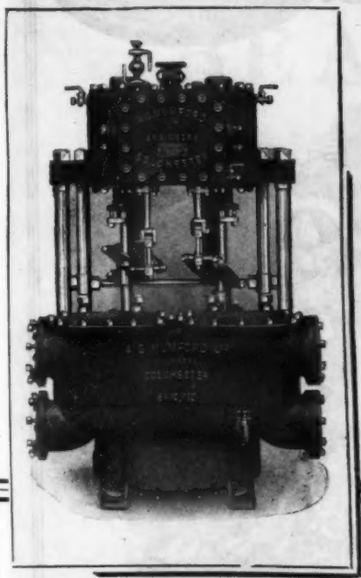
CONTRACTORS TO
BRITISH ADMIRALTY, WAR OFFICE, INDIA OFFICE, CROWN AGENTS FOR THE COLONIES, AND FOREIGN NAVIES.

IMPROVED "DUPLEX"

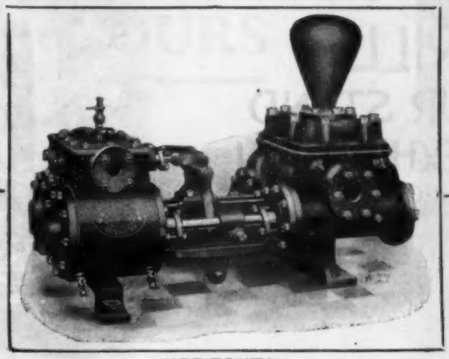
STRONGEST BEST FINISHED IN THE MARKET

Pumps

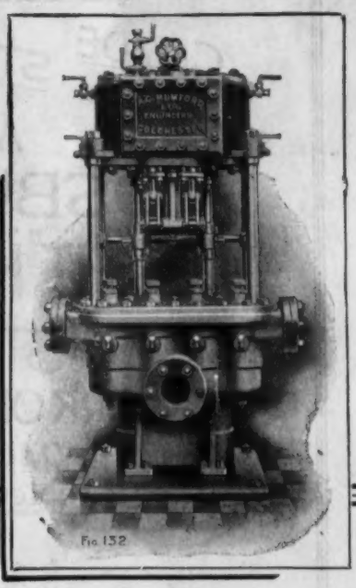
FOR ALL DUTIES.



LOW SERVICE PUMP
FITTED WITH MUMFORD'S ADJUSTABLE
"ICEBERG" VALVE GEAR.



HORIZONTAL
BOILER FEED PUMP.



2330

VERTICAL
BOILER FEED PUMP,
MARINE PATTERN.

FULL PARTICULARS & ILLUSTRATED CATALOGUE ON APPLICATION.

CONSTRUCTIONAL IRON & STEEL WORK OF ALL KINDS

GALVANIZED CORRUGATED SHEETS

GALVANIZED IRON BUILDINGS

JOHN LYSAGHT, Limited.

Bristol, Newport (Mon.), London.

CHIEF OFFICES: ST. VINCENT'S IRONWORKS, BRISTOL.

LONDON OFFICES: 36, GRACECHURCH STREET, E.C.

5937

Aeroplane Workshop 200 ft. by 200 ft. (with North Light Roofs), designed, constructed and erected by us.

BRIDGES. GIRDERS. ROOFS. BUILDINGS.

IRON & STEEL TANKS, CISTERNS, DOORS, SASHES, CHIMNEYS.

SAMUEL OSBORN & Co LIMITED.

CLYDE STEEL WORKS SHEFFIELD.

AN

OSBORN'S

"MUSHET" HIGH-SPEED

TWIST DRILL

AT WORK ON OUR STAND

AT THE OLYMPIA EXHIBITION

September 1920

SEND FOR OUR LIST 'B'

WE CAN DELIVER FROM STOCK.

NAPIER BROTHERS, LIMITED,

130, HYDEPARK STREET,

GLASGOW, W.

Telegrams: *"WINDLASS, GLASGOW."*

Telephone: *6714 CENTRAL.*

Contractors to ADMIRALTY, COLONIAL AND FOREIGN GOVERNMENTS.

Patentees and Manufacturers

of

STEAM, HAND AND ELECTRICAL

WINDLASSES, CAPSTANS, STEERING GEARS, WINCHES.

8849

Worm, Spur and Bevel Gear-cutting a Speciality.

Use
HOFFMANN BEARINGS
On your Product
AND THEIR FAME WILL BE YOURS

4615

THE HOFFMANN MFG. CO., LTD.,
CHELMSFORD, - - - ESSEX.

Plan of Door.

Cross-Section on Major Axis.

"The most satisfactory tank door made."

SUCH is the universal opinion of Mullan's Patent Door. It is a neat, sound, efficient job and no special tools are required for fitting this door to the tank top.

For FLUSH MANHOLE COVERS *always specify*

MULLAN'S PATENT DOOR

Sizes kept in Stock:	
24×15×$\frac{3}{8}$	18×14×$\frac{5}{16}$
21×15×$\frac{3}{8}$	18×13×$\frac{5}{16}$
20×13×$\frac{3}{8}$	16×12×$\frac{5}{16}$

7611

Order from the sole makers

CHARLES McNEIL Ltd.
Kinning Park Hydraulic Forge,
GLASGOW. : : :

Telegrams: "MacNeil, Glasgow."
Telephones: Ibrox 820, 1, 2 and 3.

DUNCAN STEWART & Co LTD

LONDON ROAD IRON WORKS, GLASGOW.

PATENT HIGH SPEED FORGING PRESSES

fitted with Inverted Intensifiers and New Type Valve Gear.

Our Presses are the quickest working and most up-to-date on the market.

We have recently introduced important Improvements in Forging Press construction.

Our new Valve Gear is the safest, easiest to manipulate, simplest to understand, and has fewer parts than any yet introduced.

800-TON FORGING PRESS

Steam is automatically admitted to the lifting cylinders without complicated and unreliable trip gears.

There is no leakage of steam at our lifting cylinder valves.

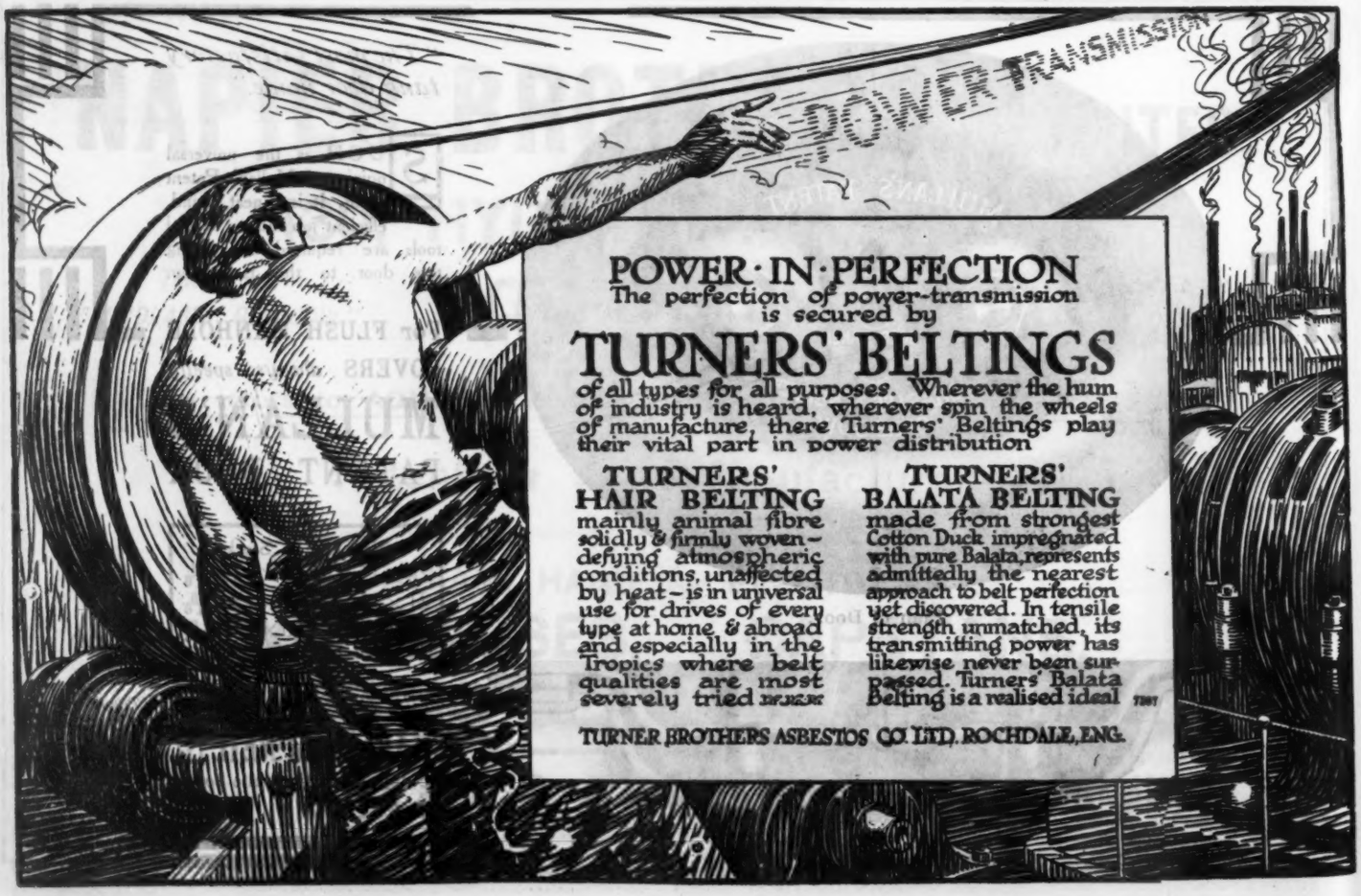
6526

Our Presses economise steam.

WE INVITE USERS TO COME AND SEE THESE PRESSES AT WORK

ALSO OTHERS IN COURSE OF CONSTRUCTION,

FITTED WITH OUR PATENT THREE POWER INVERTED INTENSIFIER.



POWER·IN·PERFECTION

The perfection of power-transmission is secured by

TURNERS' BELTINGS

of all types for all purposes. Wherever the hum of industry is heard, wherever spin the wheels of manufacture, there Turners' Beltings play their vital part in power distribution

TURNERS' HAIR BELTING mainly animal fibre solidly & firmly woven—defying atmospheric conditions, unaffected by heat—is in universal use for drives of every type at home & abroad and especially in the Tropics where belt qualities are most severely tried

TURNERS' BALATA BELTING made from strongest Cotton Duck impregnated with pure Balata, represents admittedly the nearest approach to belt perfection yet discovered. In tensile strength unmatched, its transmitting power has likewise never been surpassed. Turners' Balata Belting is a realised ideal

7201

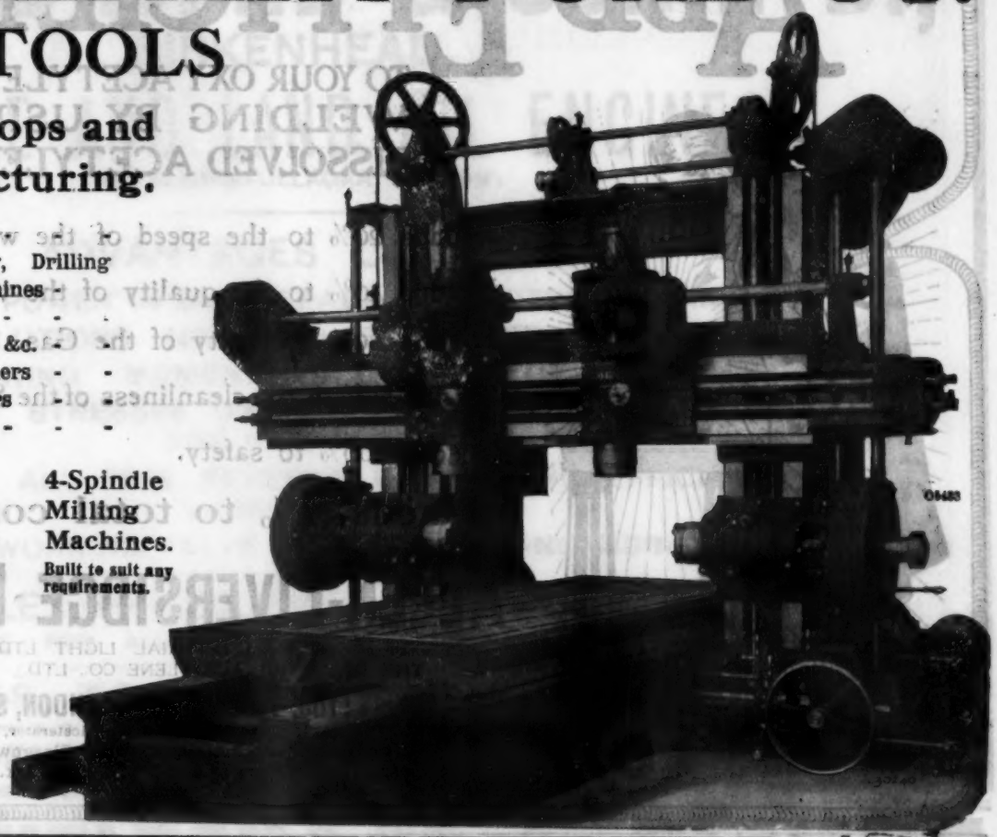
TURNER BROTHERS ASBESTOS CO. LTD. ROCHDALE, ENG.

NILES-BEMENT-POND CO.

MACHINE TOOLS

For Railroad Shops and General Manufacturing.

Engine Lathes -	Boring Mills
Gun Lathes - -	Horizontal Boring, Drilling
Projectile Lathes	and Milling Machines -
Slotters - -	Bending Rolls - - -
Steam Hammers-	Hydraulic Presses, &c. -
Standard Planers	Armour Plate Planers - -
Rotary Planers -	Boiler Plate Planers - -
Radial Drills -	Travelling Cranes - - -
&c.	&c.



4-Spindle Milling Machines.
Built to suit any requirements.

For Railroad and Repair Shops.

LATHES, Driving Wheel: 51 in. to 90 in. swing. Car Wheel. Axle.
WHEEL PRESSES: Capacities, 300 to 600 tons, and to take wheels from 42 in. to 90 in.
CAR WHEEL BORING MACHINES, to take wheels up to 42 in.
AXLE CENTERING AND CUTTING-OFF MACHINES.
WHEEL QUARTERING MACHINES.
STEAM HAMMERS: single and double frame.
STEAM DROP HAMMERS.
CRANES, TRAVELLING CRANES, HOISTS, &c.

General Offices: 111, Broadway, New York.
LONDON OFFICE: 25, Victoria Street, S.W.
For Canada: The John Bertram & Sons Co., Ltd., Dundas, Montreal, Toronto, Winnipeg, Vancouver.

BAND SAWING -MACHINES-

FOR ALL PURPOSES.

(Patent No. 29385.)

We have specialised in these Machines for over thirty years and have received thousands of repeat orders.

NEW FEATURES:

All wear on gears due to cuttings dropping on them **avoided** by our Patented Overhead Drive.

Patent Swivel Table, Feed Gear Box for instantaneous change of feed, New Top Guide adjust instantly to correct position of table when swivelled.

1400

OVER 3500 MACHINES SOLD.

NOBLE & LUND, Ltd., *FELLING-ON-TYNE.*

ADD EFFICIENCY

TO YOUR OXY ACETYLENE WELDING BY USING DISSOLVED ACETYLENE

It adds 20% to the speed of the welder.

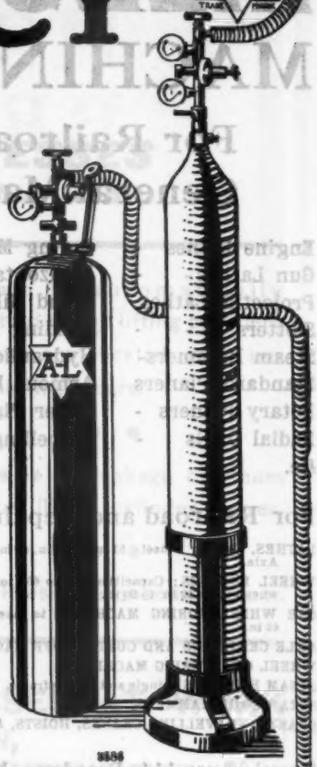
It adds 40% to the quality of the weld.

It adds 60% to purity of the Gas.

It adds 80% to the cleanliness of the Shop.

It adds 100% to safety.

It adds 0% to total cost.



ALLEN-LIVERSIDGE LTD.

(With which are amalgamated IMPERIAL LIGHT LTD., and THE DISSOLVED ACETYLENE CO., LTD.),

HEAD OFFICE: 106, VICTORIA ST., LONDON, S.W. 1.

Telephone: 4155 Victoria. Telegrams: "Acetorator, London."

Branches and Factories: Belfast, Cardiff, Glasgow, Hull, London, Newcastle-on-Tyne, Sydney, New York.

DEPARTMENTS:

MACHINERY. ENGINEERS' TOOLS. ELECTRICAL PLANT.
LOCOMOTIVES & CRANES. *CONTRACTORS' PLANT.*
RAILS & ACCESSORIES. STRUCTURAL STEELWORK.
BOILERS & TANKS. PIG IRON.
SCRAP IRON & METAL.
OBSOLETE TONNAGE.
DISMANTLING.
OLD METALS.
COAL. COKE.
MINERALS.

TELEGRAMS—"FORWARD, SHEFFIELD."

THOS. W. WARD LIMITED,

ALBION WORKS, SHEFFIELD.

TELEPHONES—4321 (8 LINES).

BRANCH WORKS:

CHARLTON WORKS, TINSLEY WORKS, } SHEFFIELD.

SILVERTOWN.
PRESTON. MORECAMBE.
BRITON FERRY. SWANSEA.
WISHAW.

London City Office: 18, BILLITER ST., E.C. 3.

CAMMELL LAIRD & CO., LTD.,

BIRKENHEAD.

MARINE AND LAND OIL ENGINES

(CAMELLAIRD-FULLAGAR SYSTEM).

ADVANTAGES CLAIMED.

50% MORE POWER IN SAME SPACE OVER OTHER ENGINES.
LOW REVOLUTIONS AND HIGH PROPELLER EFFICIENCY.
EVEN TURNING MOMENT AND PERFECT BALANCE.
NO DIRECT STRESSES ON FRAMING AS PISTON LOADS ARE BALANCED.
LOADS ON ALL PINS REVERSIBLE, ENSURING EFFICIENT LUBRICATION.
ONLY ONE WORKING VALVE PER CYLINDER—NO VIBRATION.

8474

SIMPLE. — SILENT. — RELIABLE.

SUITABLE FOR ALL CLASSES OF MERCHANT VESSELS.

LICENSES TO MANUFACTURE GRANTED.

LONDON: 3, CENTRAL BUILDINGS, WESTMINSTER, S.W. 1.

COWANS, SHELDON & CO., LD., CARLISLE

Telegrams:—"ST. NICHOLAS, CARLISLE."
LONDON OFFICE:—3, VICTORIA STREET, WESTMINSTER.
A 1 and A B C
(5th Edition) CODES USED.

CRANES

ELECTRIC TRANSPORTER.

ELECTRIC
STEAM
OR HYDRAULIC

TRAVERSERS

CAPSTANS. TURNTABLES. TRANSPORTERS.

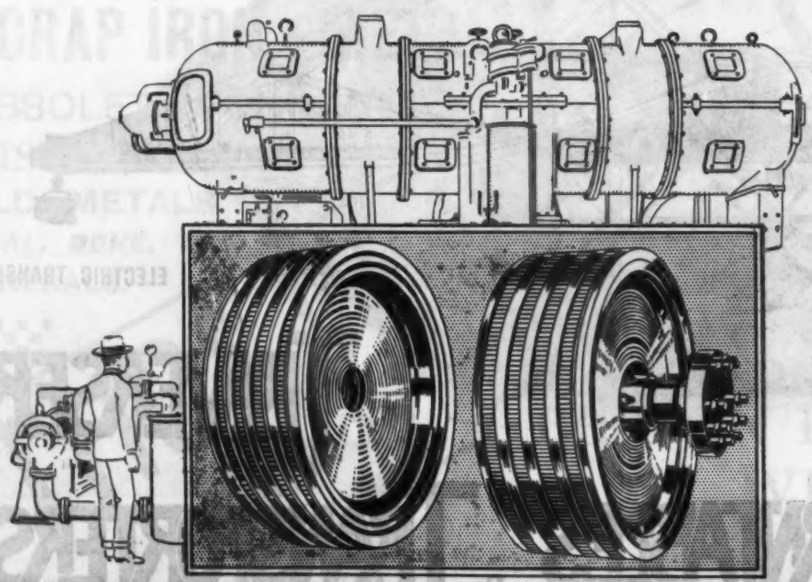
F

GLENFIELD & KENNEDY LTD.,
HYDRAULIC ENGINEERS,
KILMARNOCK, SCOTLAND.

Wish their many Friends
in all parts of the world
the Compliments of the
Season.

The BRUSH-LJUNGSTROM TURBINE

LIGHTEST & MOST EFFICIENT OF ALL STEAM PLANT



Enquiries should be addressed to

8977

The BRUSH Electrical Engineering Co. Ltd
LOUGHBOROUGH
ENGLAND

THE GLOBE PNEUMATIC ENG. CO. Ltd.

"G.P.E." TOOLS are BRITISH made throughout.

"G.P.E."

CHIPPING, CAULKING AND RIVETING HAMMERS
SAND RAMMERS
BOILER SCALERS
RIVET BREAKERS
YOKE, JAM AND SHELL RIVETERS
HAMMER TYPE HOLDERS ON

"G.P.E."

DRILLING, TAPPING AND REAMING MACHINES
SURFACE GRINDERS AND CORNER DRILLS
AIR COMPRESSORS AND COMPLETE PNEUMATIC PLANTS

REPRESENTATIVES ABROAD.

GILBERT LODGE & CO., 109, Pitt Street, Sydney, Australia.
HERBERT G. TEAGLE, Ltd., Wellington, N.Z.
JOHN E. MINNITT, Ltd., Ballard Road, Bombay.
Ste. An. LES OUTILS PNEUMATIAUES GLOBE, 58, Rue des Mathurins, Paris.
TEKNISK CO., Dronningensgt 14, Christiania.
FRANTS ALLING, Puggaardsgade 4, Copenhagen.
Dr. T. SHIN, No. 1, Mitsu Bishi Building, 1, Yayesucho Itchome, Kojimach-Ku, Tokyo
S. SMITH & SONS, Siam.
WILLIAM TIPLADY, Rue Theophilo, Ottoni 24, Rio de Janeiro.
ANDERSON, LEVANTI & CIA., 471, Calle Alsina, Buenos Ayres.
C. W. MURATOFF & CO., 22, Newsky, Petrograd.
ITALIAN GLOBE PNEUMATIC CO., Via Principe Umberto, 17, Milan.

REPRESENTATIVES IN GREAT BRITAIN.

J. F. WOLFF & CO., Ltd., Sanctuary House, Tothill Street, London, S.W. 1.
EDMISTON BROWN & CO., 219, St. Vincent Street, Glasgow,
THE GLOBE PNEUMATIC ENG. CO., Ltd., 24, Grainger Street West, Newcastle-on-Tyne.
R. DUDLEY WOOD, M.I.M.E., 24, State Insurance Buildings, 14, Dale Street, Liverpool.
JAMES TURNBULL & CO., 3, New Street, Birmingham,
GASKELL, WALKER & CO., Standard Buildings, City Square, Leeds (Manchester District and Yorkshire).

TELEGRAMS . . . "PNEUMATOID, VIC, LONDON."
TELEPHONE . . . . 2671 VICTORIA.

O 8611

1, VICTORIA STREET, LONDON, S.W. 1.

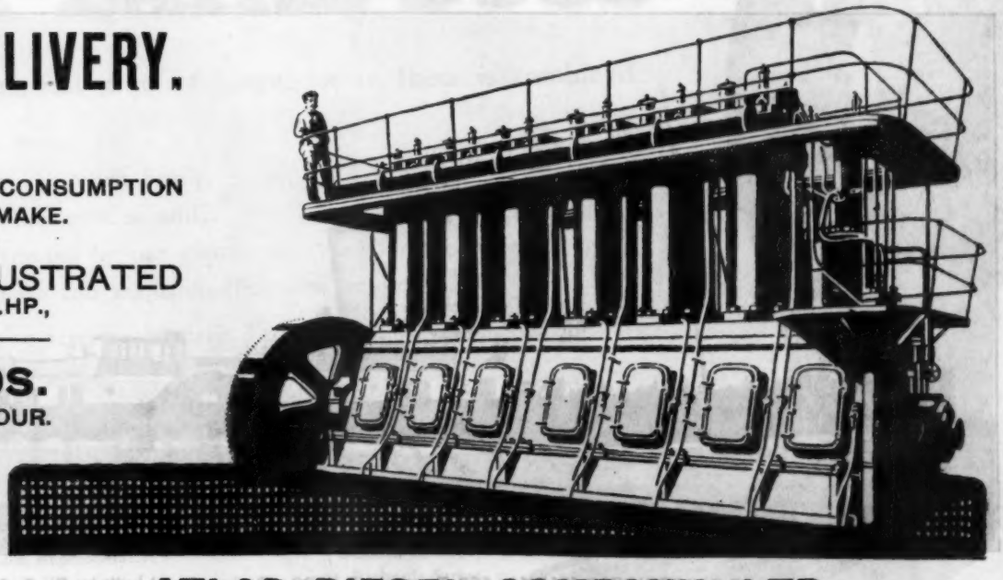
POLAR DIESEL ENGINES

IN STANDARD SIZES 12½ to 1000 B.HP. FOR INDUSTRIAL PURPOSES.

IMMEDIATE DELIVERY.

LOWER GUARANTEED FUEL CONSUMPTION THAN ANY OTHER MAKE.

FOR THE ENGINE ILLUSTRATED
Type B 6 W., 1000 B.HP.,
ONLY
0·385 lbs.
PER B.HP. PER HOUR.



8052

ATLAS DIESEL COMPANY, LTD.,
35, SURREY STREET, LONDON, W.C. 2.

WRITE FOR CATALOGUE.

Telegrams: "DIESELMOT, LONDON." Telephone: CENTRAL 9067.

CAMPBELL CAMPBELL

DEPENDABLE POWER UNIT.

8133

ELIMINATES COAL WORRIES.

200 B.H.P. Crude Oil Engine.

THE CAMPBELL GAS ENGINE CO LTD., HALIFAX, ENGLAND.

DAY, SUMMERS & CO., Ltd.,

Northam Iron Works, SOUTHAMPTON.

Telephone—No. 48. Telegrams—"DAY, SUMMERS, SOUTHAMPTON.

MANUFACTURERS OF BRITISH KROMHOUT MARINE OIL ENGINES For full Particulars Prices &c. apply to PERMAN & CO. LTD. 82-83 Fenchurch Street LONDON E.C.4

ENGINEERS, BOILERMAKERS, SHIP & YACHT BUILDERS.

P.S. "PRINCESS MARY." 558 Tons. I.HP. 1000. Designed and built by D., S. & CO., Ltd.

8331

Specialities:—STEAM TRIPOD TRAVERSING SHEERS (Land and Floating), and HAULING-UP SLIP MACHINERY.

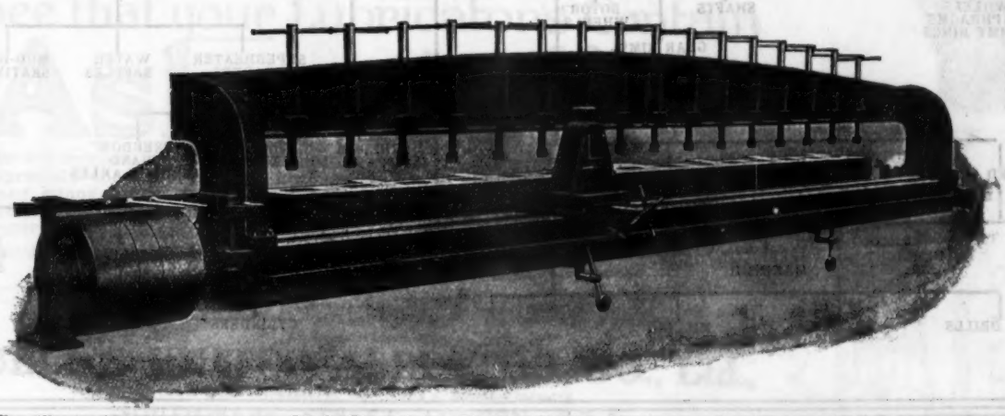
FRANCIS BERRY & SONS,

SOWERBY BRIDGE, ENGLAND.

MAKERS OF

HEAVY MACHINE TOOLS

Established 1832.



The Illustration represents our 30 ft. Plate Edge Planing Machine. Arranged for Motor Drive if required.

WILLIAMS' "VULCAN" DROP-FORGED SAFETY LATHE DOGS

STAND up under the hardest kind of usage, for in them is combined:

Quality—that resists wear.
Strength—that holds the work firmly.
Balance—that holds the work steadily.
Service—that is warranted by our guarantee. And for the operator
Safety—that is absolute and unqualified because automatic.

Bent and Straight Tail, one or two screws; 16 sizes, $\frac{3}{8}$ to 6 inches capacities.

Ask for Booklet.

8560

J. H. WILLIAMS & CO.

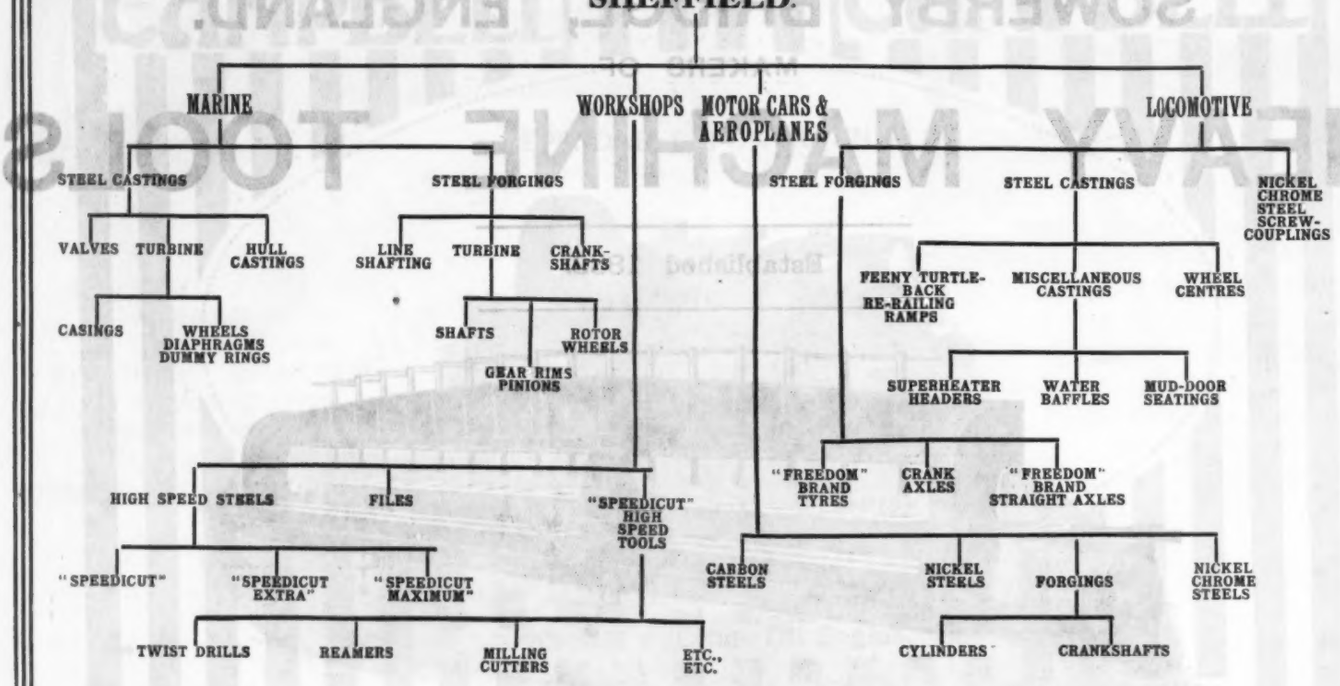
"The Drop-Forging People."

Export Office: 91, State Street, New York, U.S.A.

London Representative: Benjamin Whittaker, Ltd., Dept. H., 56, Ludgate Hill, E.C. 4.

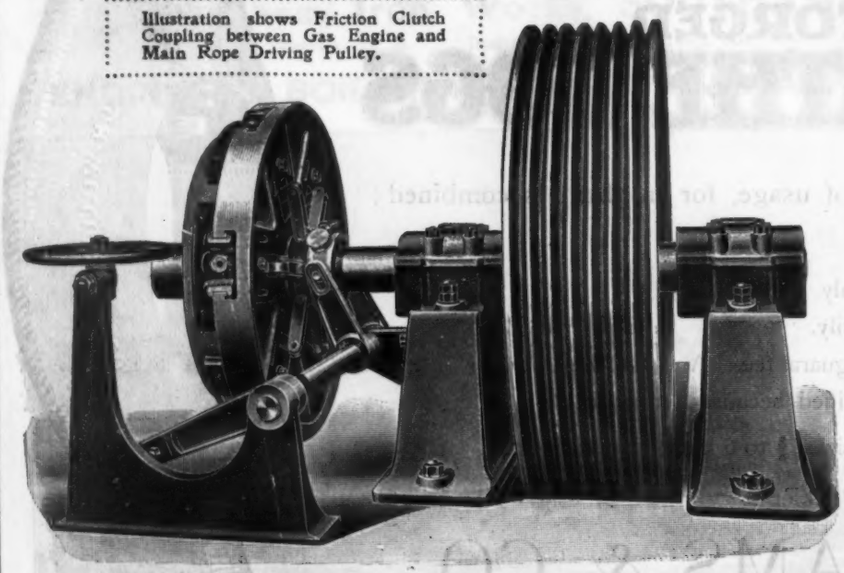
General Offices: 91, Richards Street, Brooklyn, N.Y., U.S.A.

THOS. FIRTH & SONS, LTD.
SHEFFIELD.



POWER TRANSMISSION.

Illustration shows Friction Clutch Coupling between Gas Engine and Main Rope Driving Pulley.



We Specialise
in the manufacture of

FRICTION CLUTCHES, COUPLINGS, PULLEYS, SHAFTING, GEARING, BEARINGS, and everything for the mechanical transmission of power.

SEND US YOUR ENQUIRIES.

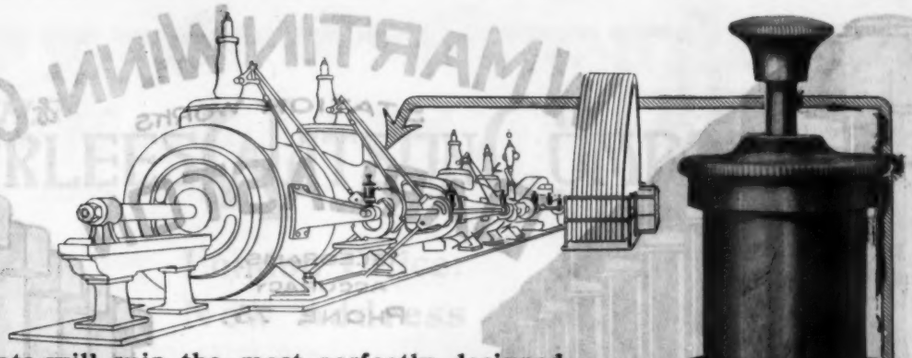
FRANK WIGGLESWORTH & CO. LTD., SHIPLEY, Yorks.

LONDON:
7, King's House, King Street, E.C. 2.
Telephone—CENT. 2611

MANCHESTER:
Royal Exchange, Pillar No. 116
(TUESDAYS and FRIDAYS).

GLASGOW:
93, Hope Street.
Telephone—CENTRAL 210.

From the Power Unit to the Machine



Inferior lubricants will ruin the most perfectly designed and constructed engine—ASBESTOLINE will improve it.

See that your Lubricators Contain

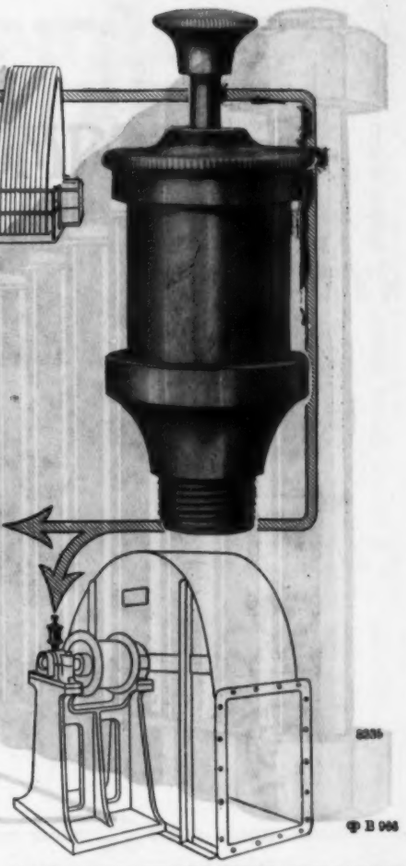
Asbestoline

You will immediately appreciate the difference in the running of your engine. You'll appreciate that "ease," that absence of "jar," the total elimination of those many minor defects which can only be attributed to inefficient lubrication. Let ASBESTOLINE show you how much longer your "brasses" will last—how much longer your bearings will bear the strain of high-pressure production.

Asbestoline does not 'drip' or 'scatter' and is, therefore, particularly *clean.*

The four grades are as follow:

A.—For ordinary engines and machinery in and out of doors.
B.—Is slightly more solid than "A" and is of use in many cases where a slightly stiffer grease is required.
C.—For use in high temperatures.
C.C.—Specially suitable for steam-heated bearings (Collar Machines, &c.).



Full particulars from:—

BELL'S UNITED ASBESTOS CO., Ltd.,

(EST. 1871). Pioneers of the World's Asbestos Industry.

SOUTHWARK STREET, LONDON, S.E. I,

8235

Φ B 906

NOTICE OF REMOVAL

Please note that we are closing our Lionel Street Factory and Offices and are removing the plant to our New Works at **SELLY OAK,** on and after JANUARY 1st, 1921, therefore, the address of our HEAD OFFICES AND WORKS will be

Dale Road, Selly Oak, Birmingham.

Telegraphic Address: "TUDOR, BIRMINGHAM." Telephone No.: SELLY OAK 26 (Temporary).

H. W. WARD & CO., LTD.

MACHINE TOOL MAKERS.

(CAPSTAN & TURRET LATHE SPECIALISTS).

8234

Before you add

that extra length of Chimney Stack

may we point out that to produce Draught by that means requires 20% to 25% of the total heat units in the fuel.

But with the

TRADE SIROCCO MARK

Induced Draft System

the running cost would not exceed 1% to 2% of the total steam generated.

This system is positive: it is absolutely independent of atmospheric conditions; low grade fuel may be used, and the waste heat going to atmosphere reduced to a minimum by means of superheaters and economisers.

LET US SEND YOU PARTICULARS.

DAVIDSON & CO., LIMITED,

Sirocco Engineering Works,
BELFAST.

8590

THE MIRRLEES WATSON COMPANY LTD.

London Office:
New Address

'MIRRLEES' HOUSE,
7, Grosvenor Gardens,
S.W. 1.

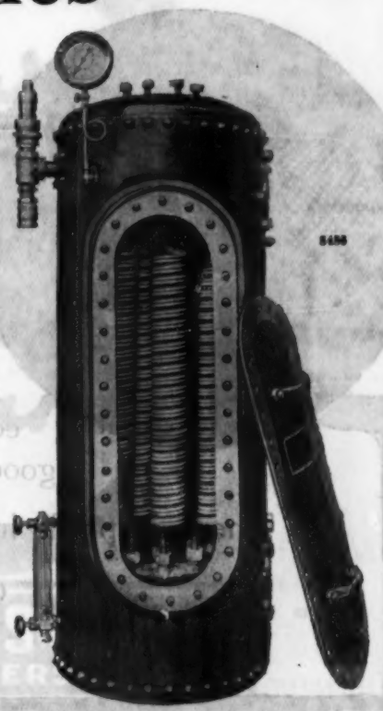
Telephone: 9123 VICTORIA. Telegrams: "MIRRLEES, SOWEST, LONDON."

Head Office and Works: SCOTLAND STREET, GLASGOW.

7957

Marine Auxiliaries

FEED WATER HEATERS.
FUEL OIL HEATERS.
COMPLETE DISTILLING PLANTS.
FILTERS.
STRAINERS.
LUBRICATING OIL COOLERS.



Reilly Navy Type Heater.

The Griscom-Russell Co.,
95, West Street, New York, U.S.A.

Cable Address: "Grispen, New York."

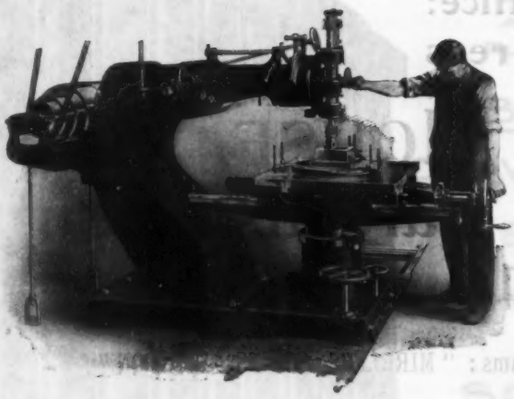
For England: W. Christie & Grey, Ltd., 4, Lloyd's Avenue, London, E.C. 3.
Telegraphic Address: "TYPHAGITOR." Telephone: AVENUE 1321.

G

Wadkin

Mechanical Woodworker

Will reduce your pattern costs.



Most of the leading Engineers, Shipbuilders, Railway Works, Motor Body Builders, &c., have installed this machine for :—

Core-box and Pattern Work.
Recessing and Routing.
Boring, Slotting and Grooving.
Tenoning and Mortising.
Cutting Fillets and Dowels.
General Radius Work, &c.

Let us arrange a demonstration for you.

8016

Wadkin & Co. Leicester

ALWAYS WORKING.

With the expansion of industry comes the insistent demand for more tools, standard tools.

Drill breakage due to a defective chuck is unknown where JACOBS CHUCKS are used. Their improved construction embodies all the features that recommend a good chuck, ease of operation, strength and reliability.

There is profit in equipping your machines with JACOBS CHUCKS. 8043

ON SALE THROUGHOUT THE WORLD.

Address DEPT. 110.

THE JACOBS MFG. CO. HARTFORD, CONNECTICUT, U.S.A.

A Happy and Prosperous New Year

is assured in 1921 for those who "Do the Right Thing in the Right Way."

The "Right Way" to carry out Excavations is the "Ruston Way."

Say what Excavating you have to do, and leave the rest to—

RUSTON & HORNSBY LTD.,

EXCAVATING EXPERTS.

LINCOLN.

8244

'Phone: 580. *Telegrams:* Ruston-Lincoln.

London Office:—46, Queen Victoria Street, E.C.

PARTINGTON STEEL & IRON COMPANY LTD

BRITISH FIBROCEMENT WORKS, Ld.

Telephone—ERITH 89 (2 Lines).

ERITH, KENT, ENGLAND.

Telegrams—"FIBROCEMEN, ERITH, KENT."

SOLE MANUFACTURERS OF

"FIBRENT"

FIRE RESISTING · WEATHER PROOF · LIGHT · EVERLASTING · FIBRENT · REGISTERED TRADE MARK

ASBESTOS-CEMENT.

NON-CONDUCTIVE, FIRE-RESISTING, INDESTRUCTIBLE.

CORRUGATED ROOFING SHEETS.

ROOFING SLATES. FLAT SHEETS.

ACKNOWLEDGED BY THE ENGINEERING INDUSTRY AS MOST SATISFACTORY AND ECONOMICAL FOR CONSTRUCTIONAL PURPOSES.

MILLIONS OF SQUARE YARDS ARE IN USE UPON MODERN FACTORIES, AEROPLANE DEPOTS; IN FACT, EVERY TYPE OF COMMERCIAL AND DOMESTIC BUILDING.

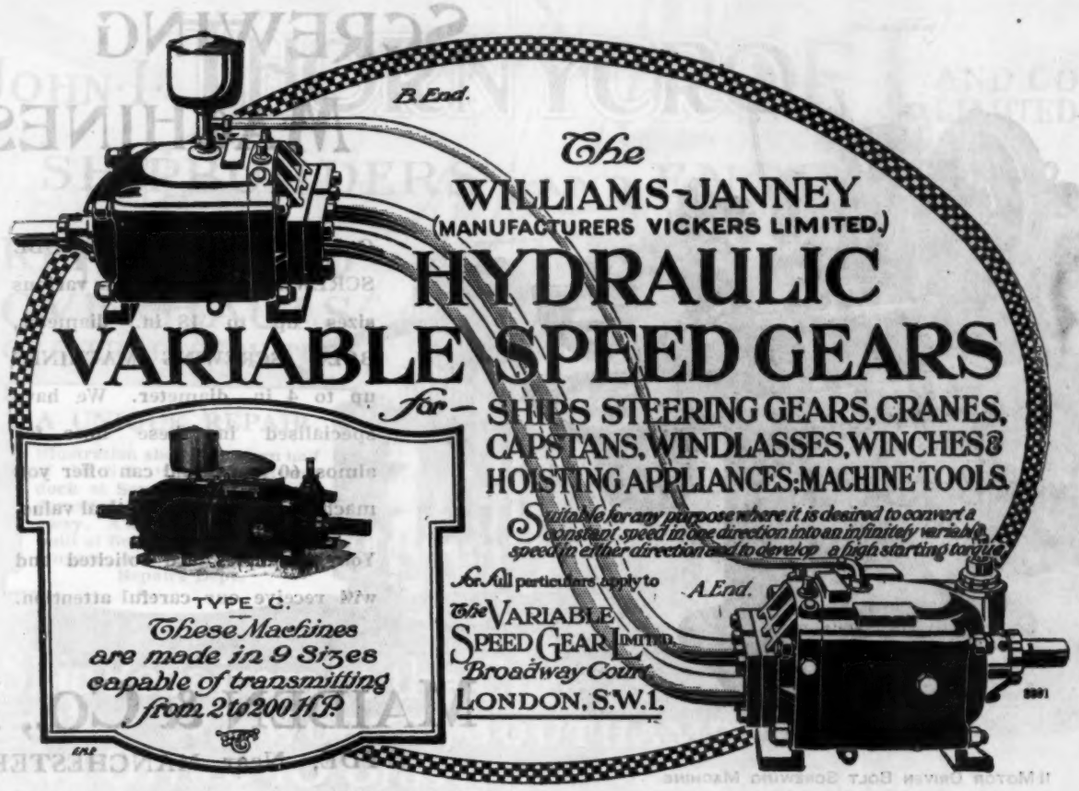
CATALOGUE UPON APPLICATION. 8929

LONDON: 22, Laurence Pountney Lane, E.C. 4. Telephone: CITY 2329.

BIRMINGHAM, 14, New Street. Telephone: CENTRAL 7292.

414, Corn Exchange Buildings, MANCHESTER. Telephone: CITY 7856.

Also at GLASGOW, BRISTOL, CARDIFF, DUBLIN and BELFAST.



The
WILLIAMS-JANNEY
(MANUFACTURERS VICKERS LIMITED.)

HYDRAULIC VARIABLE SPEED GEARS

for— SHIPS STEERING GEARS, CRANES, CAPSTANS, WINDLASSES, WINCHES & HOISTING APPLIANCES; MACHINE TOOLS.

Suitable for any purpose where it is desired to convert a constant speed in one direction into an infinitely variable speed in either direction and to develop a high starting torque.

TYPE C.

These Machines are made in 9 Sizes capable of transmitting from 2 to 200 H.P.

For full particulars apply to
The VARIABLE SPEED GEAR LIMITED.
Broadway Court,
LONDON, S.W.1.

8981

"PRECISION WITH US —IS A— COMMODITY

WE SELL IT AND BUILD IT INTO YOUR TOOLS."

OUR SPECIALITY IS THE DESIGN AND MANUFACTURE OF

JIGS & GAUGES

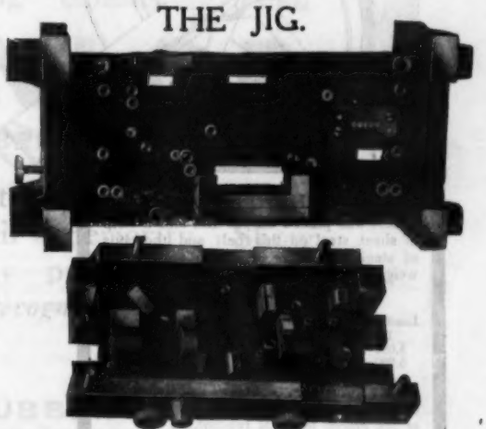
TO THE VERY FINEST LIMITS OF ACCURACY.

THE COMPONENT.

THIS JIG WAS RECENTLY DESIGNED AND MADE FOR A WELL-KNOWN TYPEWRITER FIRM.

SEND YOUR JIG PROBLEMS TO US!

THE JIG.



PRECISION GAUGES LTD.,

THE JIG SPECIALISTS,

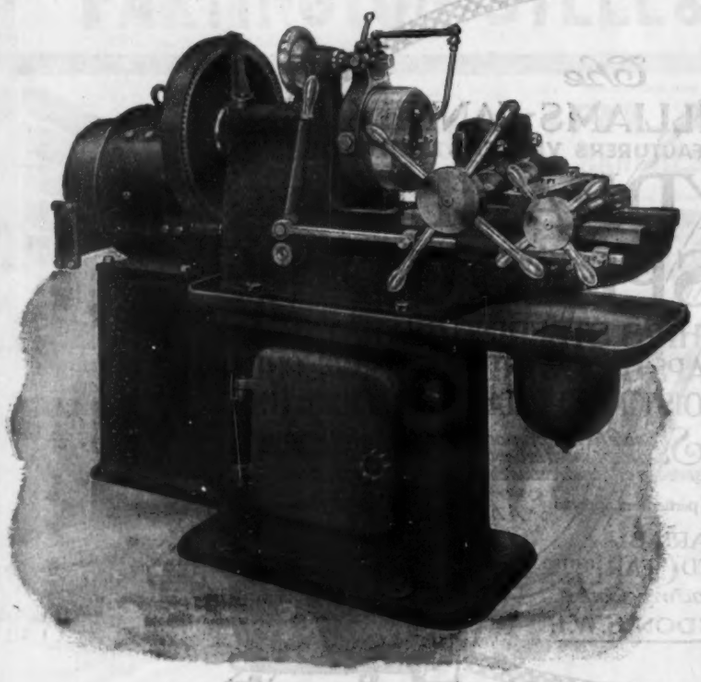
WRENTHAM STREET, BIRMINGHAM

8070

Telephone—MIDLAND 1016.

Telegrams—"REKRAP, B'HAM."

SCREWING MACHINES.



11 Motor Driven Bolt Screwing Machine with Automatic Die Head.

Our Standard Lines are TUBE SCREWING MACHINES in various sizes up to 18 in. diameter, BOLT SCREWING MACHINES up to 4 in. diameter. We have specialised in these lines for almost 60 years, and can offer you machines of proved practical value.

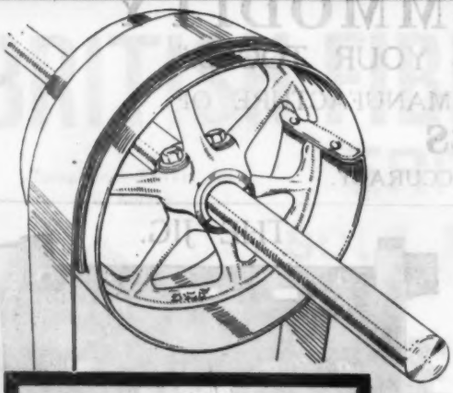
Your enquiries are solicited and will receive our careful attention.

MAIDEN & Co., LTD.,

HYDE, Near MANCHESTER.

Telephone—29 HYDE. Tel. Add.—MAIDEN HYDE

8317



THE TEST.

A belt was placed on the rim and a strip of sheet steel on this belt and the ends of steel strip were weighted with equal weights, which were gradually increased.

RESULTS.

Load lbs.	Deflection m/ms.	Difference m/ms.
110	·000	·000
3,080	·070	·070
5,600	·180	·110

With a total load of 17,850 lbs. the shaft commenced to bend. *The breaking load of the pulley was not reached.*

THE S.K.F. PULLEY IS STRONG ENOUGH FOR YOUR JOB.

SKF

SPLIT BELT

PULLEY TESTS No. 1

Compression Loading.

We have already shown in our previous advertisements how the construction of the pulley ensures great strength and absolute security, even at absurdly high peripheral speeds, though at the same time it is exceedingly light. We now commence a series of test results. This test was carried out to determine the bending of the rim which occurs when the pulley is exposed to pressure from a belt placed in the middle of the rim. The resulting figures given in the panel to the left, definitely prove the S.K.F. pulley to possess altogether exceptional strength.

Write for Catalogue.

The Skefko Ball Bearing Co., Ltd.

LUTON BEDS.

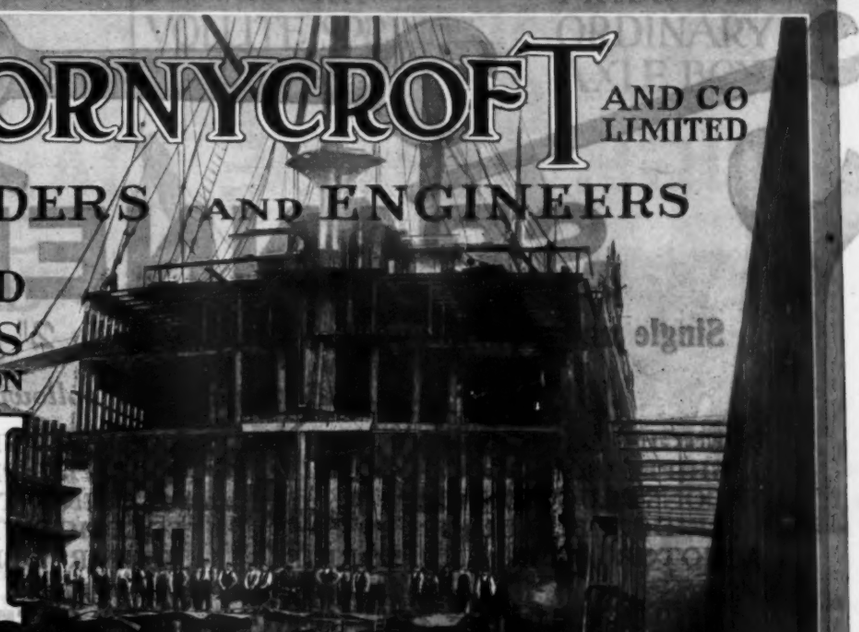
8555

Branches at—LONDON, BIRMINGHAM, MANCHESTER, LEEDS, LEICESTER, NEWCASTLE-ON-TYNE, GLASGOW, SHEFFIELD, BRISTOL, LIVERPOOL.

JOHN·I· THORNYCROFT AND CO LIMITED

SHIPBUILDERS AND ENGINEERS

REPAIRS AND OVERHAULS OF EVERY DESCRIPTION



A UNIQUE REPAIR.

Illustration shows the stern half of the S.S. "Suevic" in dry dock at Southampton and the damaged portion being cut away. A new stem portion was built at Belfast, towed to Southampton, and joined up by our Repairs Dept.

Ship Repairers to the Cunard Steamship Co Ltd.

WORKS, SOUTHAMPTON

Head Office·10 Grosvenor Place·London·S·W·1

There certainly was a huge majority of Dunlops at the Commercial Vehicle Show—

but it is *on the road,* under the most exacting conditions, that

DUNLOP

SOLID RUBBER BAND TYRES

are afforded the best opportunity of proving their superiority. Show statistics only prove that their qualities are *recognised.*

DUNLOP RUBBER CO., LTD.,
Founders of the Pneumatic Tyre Industry, BIRMINGHAM.
DUNLOP SOLID RUBBER TYRE FITTING DEPOTS:
Belfast, Birmingham, Bristol, Coventry, Dublin, Edinburgh, Glasgow, Leeds, Liverpool, London, Manchester, Newcastle-on-Tyne, Norwich, Nottingham.

Dunlop solid rubber tyres are obtainable from all leading motor dealers.

SPANNERS.

Single and Double-Ended. All sizes up to 2" supplied from stock.

***SPECIAL SPANNERS* made for following trades:—**

ENGINEERING	AGRICULTURAL IMPLEMENTS
SHIPBUILDING	RAILWAY PERMANENT WAYS
CONSTRUCTIONAL	MACHINE TOOLS
BRIDGE BUILDINGS	LOCOMOTIVES
MOTOR CARS AND LORRIES	WATER DEPARTMENTS

ARMSTRONG, STEVENS & SON, LTD., WHITTALL ST., BIRMINGHAM.

WORKS:—WILLENHALL.

8075

PRICES QUOTED ON APPLICATION.

Machine Shop and Foundry—Industrial Works, Bay City, Mich., U.S.A.

We Design, Manufacture and Erect
Steel Industrial Plants
Railroad and Highway Bridges
Lock Gates
Steel Furnace Pieces
Steel Storage Tanks
Riveted Steel Pipe
Steel Transmission Towers
Steel Ships and Barges
Oil Refining Plants
Gas Plants and Gas Holders
Ore Bridges
Etc
McClintic-Marshall
Annual Capacity, 400,000 Tons

The Power of Performance.

A TYPE of construction exemplified in over 5000 industrial buildings, designed and erected by an organization with more than twenty years' cumulative experience, and the fabricating facilities of the largest plate shops in the world—are elements that should warrant consideration from all who contemplate new construction.

McClintic-Marshall Products Company prefers to perform rather than to promise. The same engineers who built the Panama Lock Gates, the Chelsea Pier Sheds, the Beaver Bridge, and thousands of industrial buildings, are prepared to consult with you on your requirements. Our annual capacity is 400,000 tons.

Write for descriptive Booklet X 201.

McClintic-Marshall Products Company

WORKS: PITTSBURGH, U.S.A. *Foreign Contract Dept.*, 50, Church Street, NEW YORK.
Cable Address: "Macmarsh" New York.

PARIS, *Robert McKean*, 8, Rue Edouard VII. HAVANA, Obrapio, y Ignacio.

8579

International Steel Corporation, Ltd.
REPRESENTATIVES
Offices: 26, VICTORIA ST., WESTMINSTER, LONDON, ENGLAND.

RIO DE JANEIRO SANTIAGO, CHILE IQUIQUE SAO PAULO LIMA BUENOS AIRES MONTEVIDEO SHANGHAI TOKIO

McClintic-Marshall

Steel Construction

STEAM CRANES AND ELECTRIC OVERHEAD CRANES

Two Types of Shunting Cranes made up to any Lifting Capacity

Fitted with VOLUTE SPRINGS

Fitted with ORDINARY AXLE BOXES

SAMUEL BUTLER & CO. LTD.
GRANGEFIELD WORKS - STANNINGLEY Near LEEDS
Telegrams.- "Lifting" Stanningley :: *Telephone.*- 176 Stanningley PRIVATE BRANCH EXCHANGE

QUICK DELIVERIES.

ELECTRIC STEEL CASTINGS UP TO 25 CWTS.

TO ANY SPECIFICATION OR TEST.

Speciality.

Valve Bodies, Tested to 500 lbs. sq. in.

GREY IRON CASTINGS UP TO 15 TONS.

GOOD, SOUND, CLEAN, CASTINGS.

Speciality.

Light Castings from 1 lb. upwards.

QUOTATIONS GIVEN ON RECEIPT OF DRAWINGS.

THOS. BROADBENT & SONS LTD., HUDDERSFIELD.

Telegrams: Broadbent, Huddersfield.

Telephone: 1581 (4 lines).

FOR

HIGH GRADE CAST IRON

CASTINGS

FOR ENGINEERING TRADES.

WRITE:

HARDY & PADMORE, LTD., WORCESTER.

TEL. 160: WORCESTER. ESTABLISHED 1814. TELEGRAMS: "QUALITY."

9005

"BON-ACCORD"

SALVAGE PLANT

As supplied to the leading Marine Salvage Companies all over the World.

3818

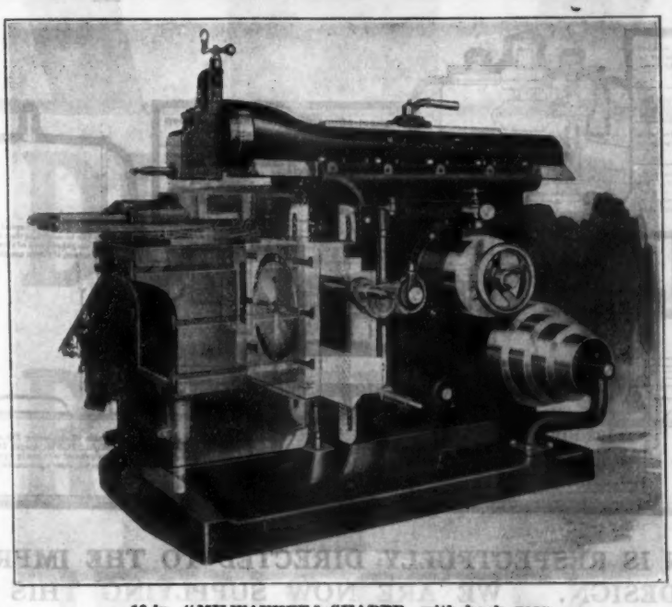
Drysdale Motor Salvage Pump pumping out one of the scuttled German War Vessels

DRYSDALE & CO., Ltd., Yoker, GLASGOW, W., Scotland.

EVERY TYPE OF MACHINE TOOL
FOR IMMEDIATE DELIVERY.

Engine Lathes.
Capstan Lathes.
Milling Machines.
Shaping Machines.
Turret Lathes.
Riveting Hammers.

1400 MACHINES IN STOCK.



16 in. "MILWAUKEE" SHAPER, with back gear.

Tool and Cutter Grinders.
Toolroom Planers.
Manufacturing Lathes.
Drilling Machines.
Disc Grinders.
Woodworkers.

1400 MACHINES IN STOCK.

INSPECTION INVITED.

8764

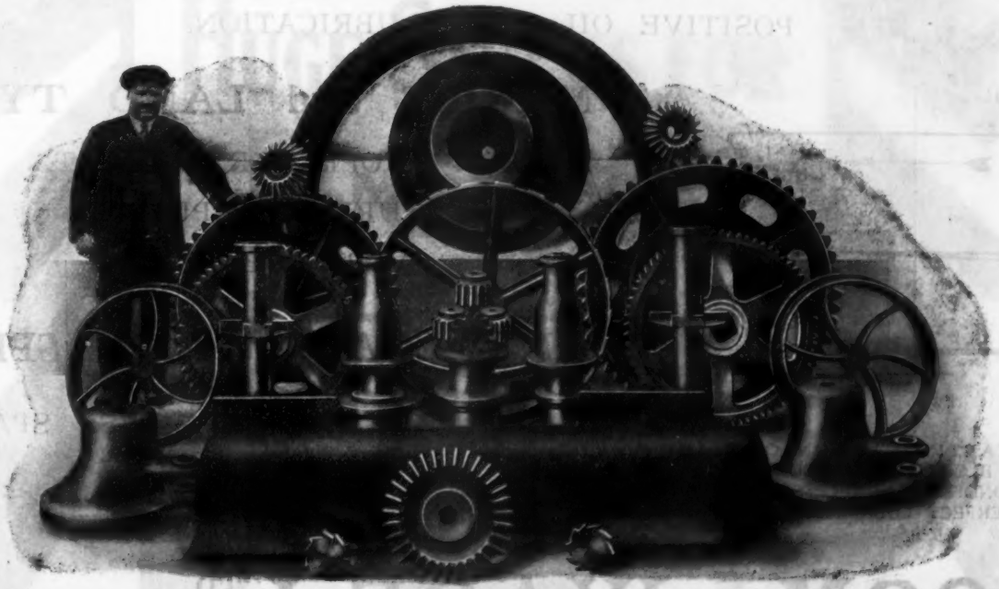
SOLE SELLING AGENTS:—

UNIVERSAL MACHINERY CORPN. LTD.,

Telegrams: TOOLCRAFT, LONDON.
326, OLD STREET, LONDON, E.C. 2.
Telephone: CLERKENWELL 1442.

HEAD, WRIGHTSON & COMPANY, LTD.

HIGH CLASS ELECTRIC FURNACE STEEL CASTINGS.



TEESDALE IRON WORKS: Thornaby-on-Tees.
FORGE WORKS: Stockton-on-Tees.

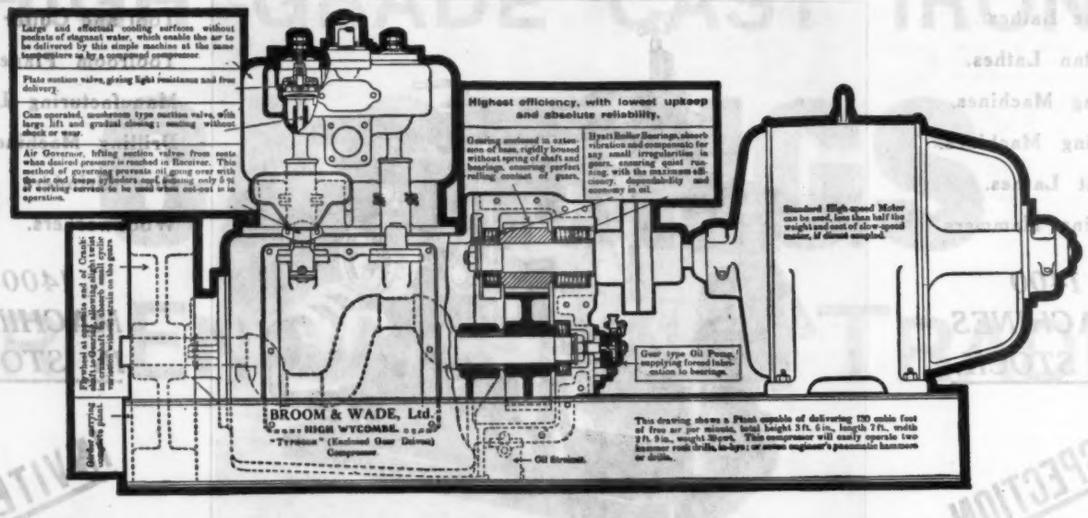
7766

Telegrams— "TEESDALE, STOCKTON-ON-TEES."

ON LLOYD'S LIST.

A New Air Compressor.

Air Compressors for all Purposes.


Large and effectual cooling surfaces without pockets of stagnant water, which enable the air to be delivered by this simple machine at the same temperature as by a compound compressor.
Plate suction valves, giving light resistance and free delivery.
Cam operated, mushroom type suction valve, with large lift and gradual closing; seating without shock or wear.
Air Governor, lifting suction valves from seats when desired pressure is reached in Receiver. This method of governing prevents oil going over with the air and keeps cylinders cool, passing only 5 per of working current to be used when out-out or in operation.
Highest efficiency, with lowest upkeep and absolute reliability.
Gearing enclosed in extension of base, rigidly housed without spring of shaft and bearings, ensuring perfect rolling contact of gears.
Hyatt Roller Bearings absorb vibration and compensate for any small irregularities in gears, ensuring quiet running with the maximum efficiency, dependability and economy in oil.
Standard High-speed Motor can be used, less than half the weight and cost of slow-speed motor, if direct coupled.
Gear type Oil Pump, supplying forced lubrication to bearings.
BROOM & WADE, Ltd. HIGH WYCOMBE. "Tyrone" (Enclosed Gear Driven) Compressor
Oil Strainer.
This drawing shows a Plant capable of delivering 120 cubic feet of free air per minute, total height 3 ft. 6 in., length 7 ft., width 3 ft. 9 in., weight 30 cwts. This compressor will easily operate two hammer rock drills, 2-in-type; or seven engineer's pneumatic hammers or drills.

Sizes: 5 to 1000 C.F.

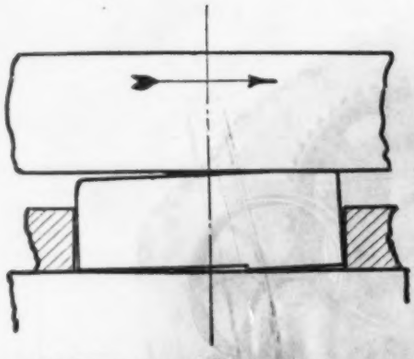
Any Drive Fixed or Portable.

YOUR ATTENTION IS RESPECTFULLY DIRECTED TO THE IMPROVED FEATURES OF THE ABOVE DESIGN. WE ARE NOW SUPPLYING THIS TYPE IN LARGE NUMBERS AND THEY ARE GIVING THE MOST EXCELLENT RESULTS.

MICHELL PATENT THRUST BEARINGS

(SINGLE COLLAR).

POSITIVE OIL FILM LUBRICATION.



NOTE CANTING ACTION OF BEARING BLOCK WHICH SECURES THE CONDITIONS NECESSARY FOR PERFECT LUBRICATION.

MARINE and LAND TYPES

FOR PROPELLER THRUST,
TURBINES, PUMPS,
WORM GEARS, &c.

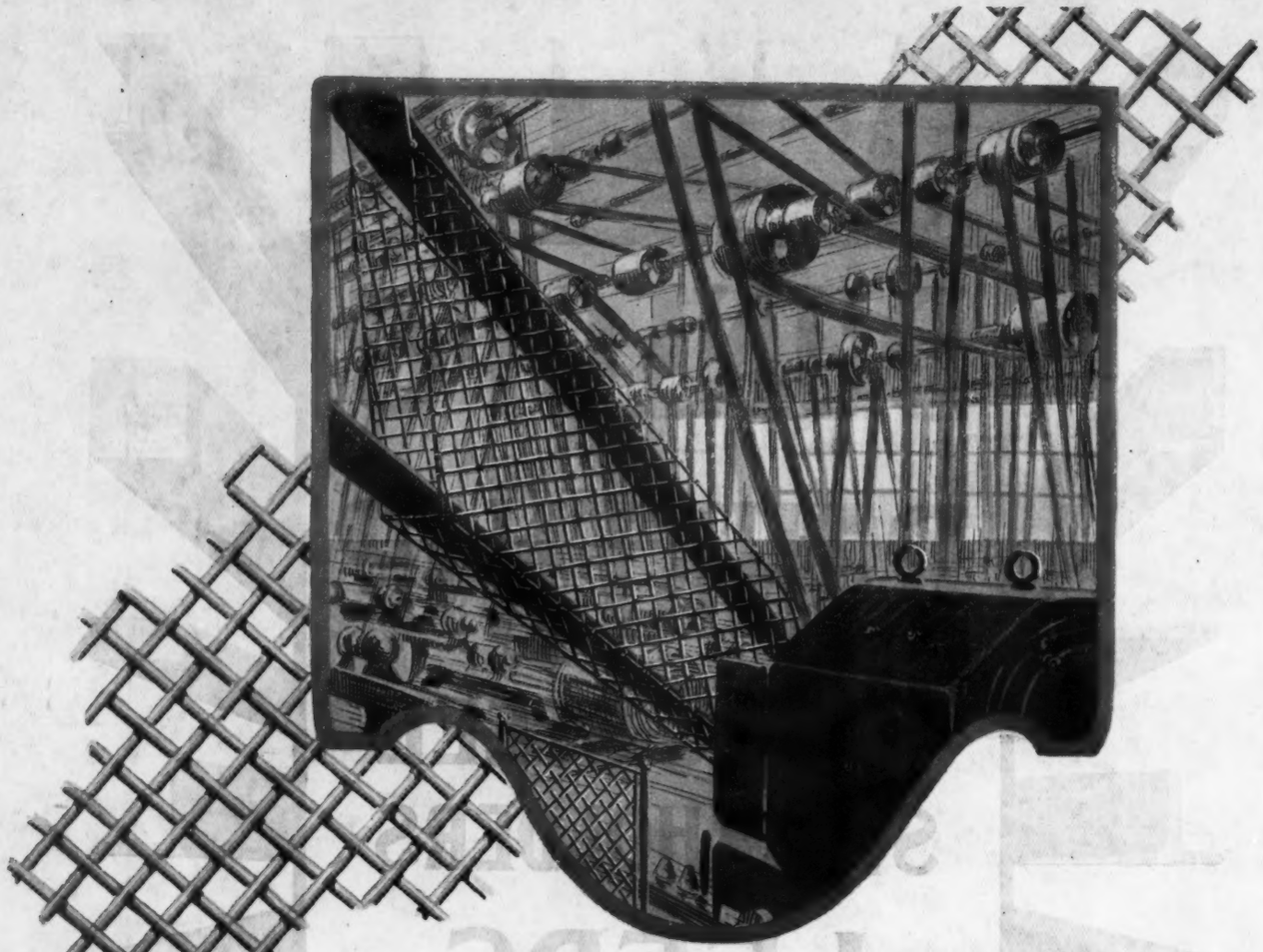
ANY LOAD at ANY SPEED

LESS FRICTION. LESS SPACE.
LESS TROUBLE.

BROOM & WADE, LTD., High Wycombe.

8911

DUNLOP &
RANKEN LTD
IRON & STEEL
STOCKHOLDERS
LEEDS
HUGE STOCKS FOR
IMMEDIATE
DELIVERY



Sturdy Links with Safety.

JOHNSON'S Wirework—highest grade drawn Steel Wire of great tensile strength—is made up into perfectly fitting guards for every type of machinery. Every mesh is a sturdy link with safety, eliminating the risk of accident—making every danger point *safe*.

Guards for:—
Machinery, *Windows*, *Hoists*, *Fires*, *Radiators*.

Johnson's Wirework is also employed for:—
Workshop Partitions, *Drying Racks*, *Letter Racks*, *Conveyor Belts*, *Wirework Lockers*, *Baskets and Trays*, *Woven Wire Screens*, *Spark Arrestors*,
Light Iron structures combined with wirework.

Special designs and quotations submitted free for all kinds of wirework or Light Iron Structures.

Write for Illustrated Catalogues.

"JOHNSON'S WIREWORK FOR ALL INDUSTRIES."

Rd. Johnson, Clapham & Morris, Ltd.,
LEVER STREET, MANCHESTER,
Works: Newton Heath, Manchester.

LONDON. LIVERPOOL. MIDDLESBROUGH. GLASGOW.
SYDNEY. MELBOURNE. BRISBANE. WELLINGTON (N.Z.).

8331

Johnson's Wirework

BEARDMORE

FOR

BETTER TRANSPORT

MAIN LINE LOCOMOTIVE, RECENTLY BUILT AT DALMUIR—
ONE OF A BIG CONTRACT FOR THE EAST INDIAN RAILWAYS.

WILLIAM BEARDMORE & CO. LTD.

PARKHEAD STEEL WORKS,

GLASGOW.

8068

LOCOMOTIVES

LONDON OFFICE.....36, VICTORIA ST, S.W.1.

Over 150,000 hp.

Of OUR Winding Equipments are giving complete satisfaction in all parts of the world.

Metropolitan - Vickers

ELECTRIC WINDERS

are specially designed and constructed to meet the arduous conditions incident to mining.

Our Engineers, with the experience of many years, are ready to be consulted and help you on any proposition you may put before us.

METROPOLITAN - VICKERS ELECTRICAL CO. LTD.,

Trafford Park —— MANCHESTER.

THE Mark of Efficiency.

8834

WEIR PUMPS

Air Pumps
Dual and Monotype

Feed Pumps
Direct-Acting and Rotary

Oil Pumps
For Cargo, Transfer and Pressure Duty

Service Pumps
For Bilge and Ballast Duty, etc.

8189

Adopted by the leading Mail, Passenger and Cargo Steamship lines throughout the World

G. & J. WEIR, Ltd. CATHCART GLASGOW

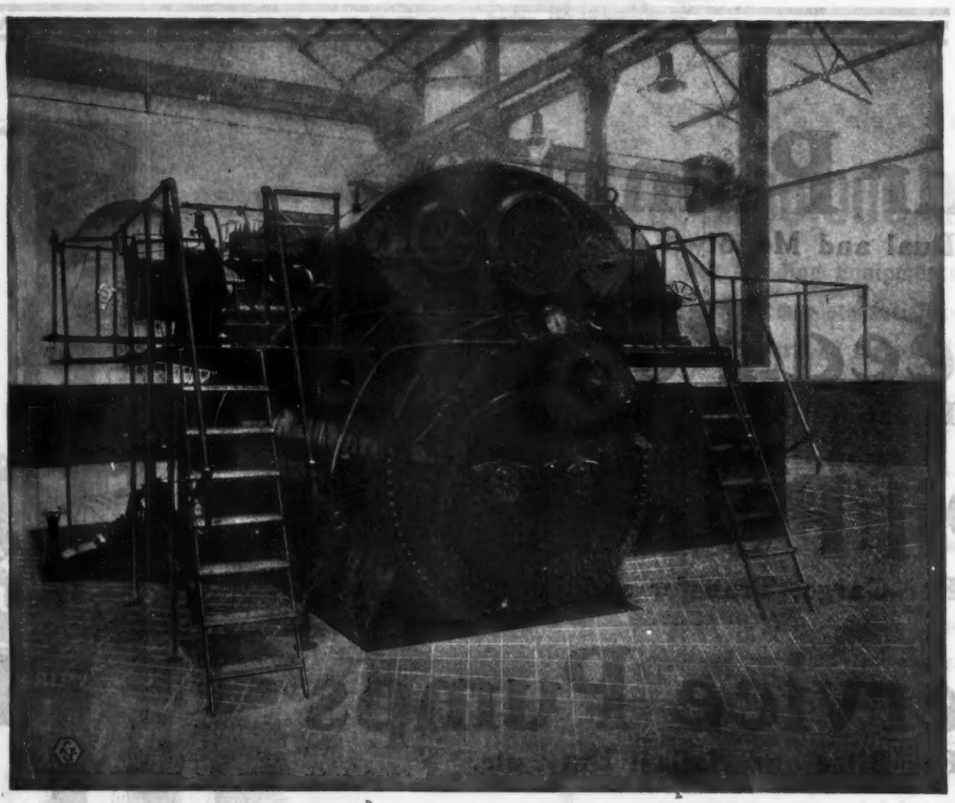
I

Telegrams: "AGROENGIC, 'PHONE. LONDON." Telephone: GERRARD 6850 (6 lines).

LOW FUEL CONSUMPTION,
REDUCED RUNNING COSTS, CONTINUITY OF OPERATION
EFFECTED BY INSTALLING A

"Garrett"

SUPERHEATED STEAM SEMI-STATIONARY POWER PLANT.



Richard Garrett & Sons, Limited.
BRANCH OF
AGRICULTURAL & GENERAL ENGINEERS, LTD.

ASSOCIATING:

Aveling & Porter, Ltd. (Rochester);
Barford & Perkins, Ltd. (Peterborough);
E. H. Bentall & Co., Ltd. (Heybridge);
Blackstone & Co., Ltd. (Stamford);
Peter Brotherhood, Ltd. (Peterborough);
Charles Burrell & Sons, Ltd. (Thetford);
Burrell's Hiring Co., Ltd. (Thetford);
Clarke's Crank & Forge Co., Ltd. (Lincoln);
Davey, Paxman & Co., Ltd. (Colchester);
Richard Garrett & Sons, Ltd. (Leiston);
James & Fredk. Howard, Ltd. (Bedford);
L. R. Knapp & Co., Ltd. (Clanfield);
E. R. & F. Turner, Ltd. (Ipswich);
A. G. E. Electric Motors, Ltd. (Stowmarket).

8438

BRIGHT STEEL BARS AND STRIP

W. WESSON & CO., LTD.

VICTORIA IRON & STEEL WORKS,

MOXLEY, WEDNESBURY.

Telegrams: "IRON, WEDNESBURY." *On Admiralty, War Office, and other Government Lists.* 7133 Telephone: 62 WEDNESBURY.

Vickers Limited.

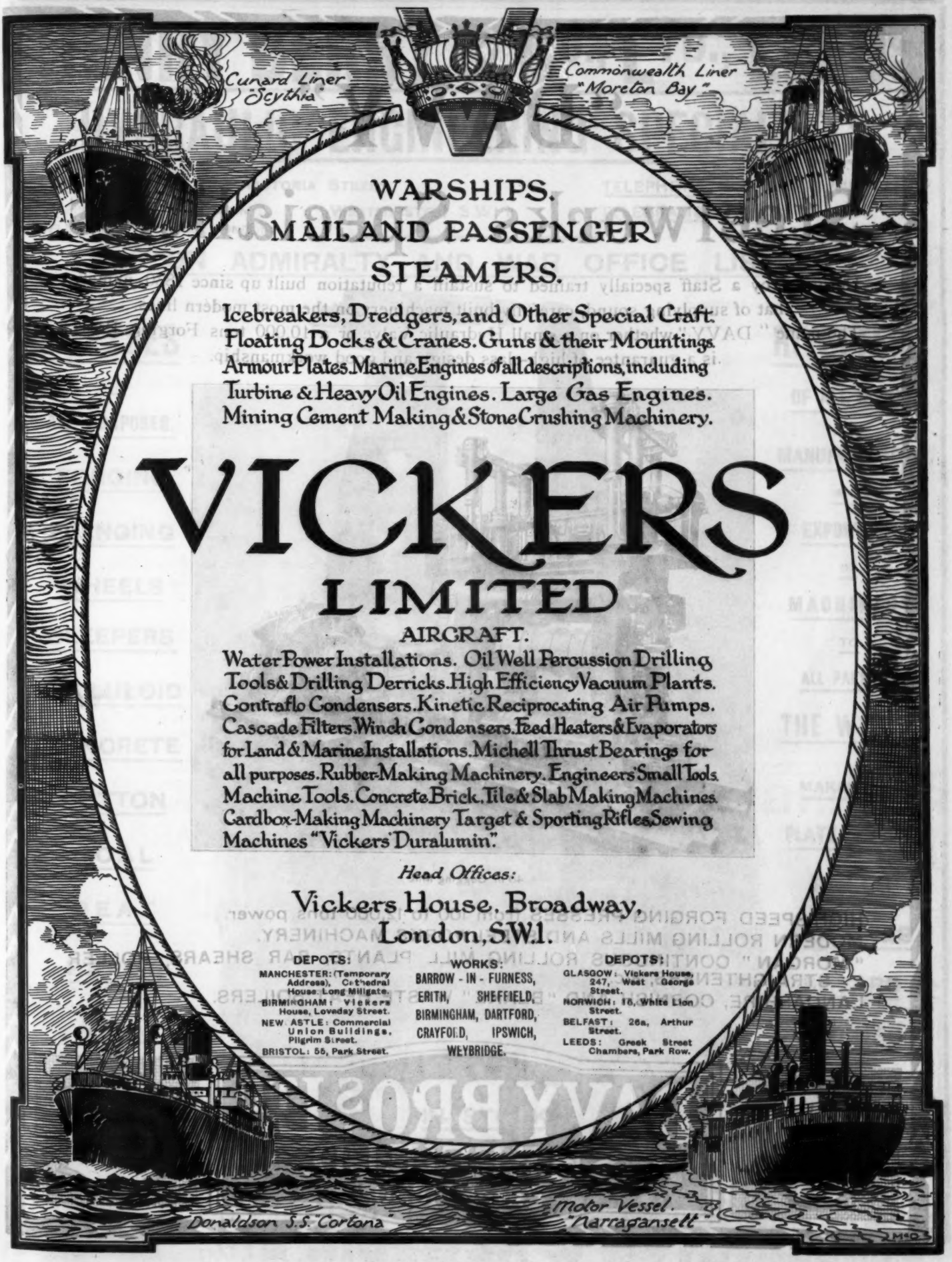
FILES

OF EVERY DESCRIPTION.

REGISTERED TRADE MARK.

River Don Works,
SHEFFIELD.

Head Office:
Vickers House, Broadway,
London. S.W.1.



WARSHIPS.
MAIL AND PASSENGER STEAMERS.

Icebreakers, Dredgers, and Other Special Craft.
Floating Docks & Cranes. Guns & their Mountings.
Armour Plates. Marine Engines of all descriptions, including Turbine & Heavy Oil Engines. Large Gas Engines.
Mining Cement Making & Stone Crushing Machinery.

VICKERS
LIMITED

AIRCRAFT.

Water Power Installations. Oil Well Percussion Drilling Tools & Drilling Derricks. High Efficiency Vacuum Plants. Contraflo Condensers. Kinetic Reciprocating Air Pumps. Cascade Filters. Winch Condensers. Feed Heaters & Evaporators for Land & Marine Installations. Michell Thrust Bearings for all purposes. Rubber-Making Machinery. Engineers' Small Tools. Machine Tools. Concrete Brick, Tile & Slab Making Machines. Cardbox-Making Machinery. Target & Sporting Rifles. Sewing Machines. "Vickers' Duralumin."

Head Offices:

Vickers House, Broadway,
London, S.W.1.

DEPOTS:
MANCHESTER: (Temporary Address), Cathedral House, Long Millgate.
BIRMINGHAM: Vickers House, Loveday Street.
NEWCASTLE: Commercial Union Buildings, Pilgrim Street.
BRISTOL: 55, Park Street.

WORKS:
BARROW-IN-FURNESS, ERITH, SHEFFIELD, BIRMINGHAM, DARTFORD, CRAYFORD, IPSWICH, WEYBRIDGE.

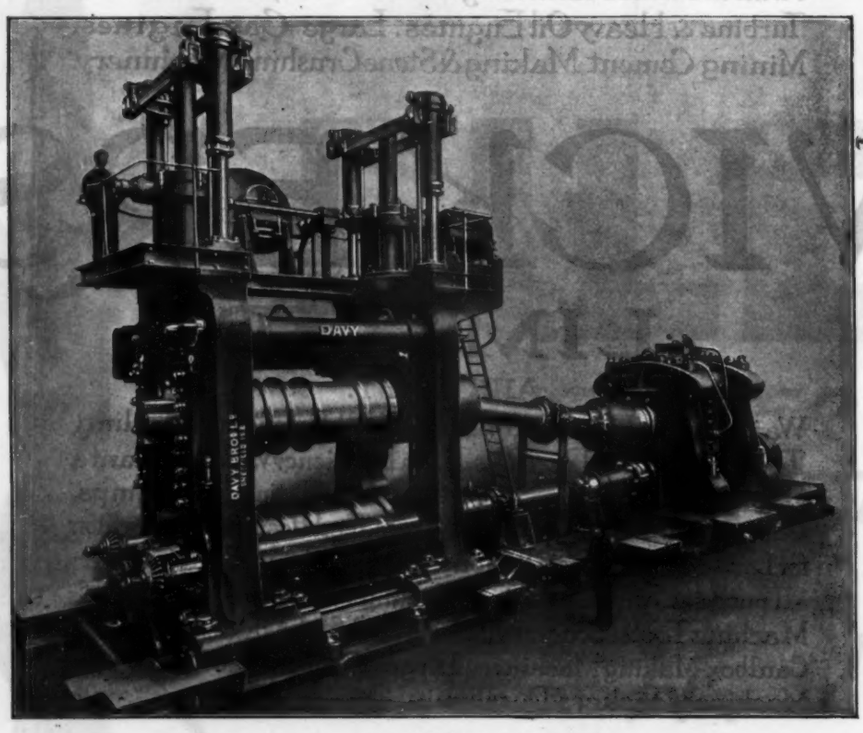
DEPOTS:
GLASGOW: Vickers House, 247, West George Street.
NORWICH: 16, White Lion Street.
BELFAST: 26a, Arthur Street.
LEEDS: Greek Street Chambers, Park Row.

Donaldson S.S. "Cortona"
Motor Vessel "Narragansett"

"DAVY"

Steelworks Specialities

Designed by a Staff specially trained to sustain a reputation built up since 1830, namely, that of supplying sound, carefully built machinery on the most modern lines.
The name " DAVY," whether on a small Hydraulic Valve or a 10,000 tons Forging Press, is a guarantee of high-class design and good workmanship.



40 in. Cogging Mill.

HIGH-SPEED FORGING PRESSES from 100 to 12,000 tons power.
MODERN ROLLING MILLS AND STEELWORKS MACHINERY.
"MORGAN" CONTINUOUS ROLLING MILL PLANTS, BAR SHEARS, ROLLER STRAIGHTENERS, &c.
LANCASHIRE, CORNISH AND "BLAKE" WASTE HEAT BOILERS.

8916

Telephone, 4800 (5 Lines)

DAVY BROS. LTD.
SHEFFIELD.
Estabd 1830.

Telegrams, "MOTOR SHEFFIELD"

HENRY BERRY & CO., LTD., LEEDS

HYDRAULIC ENGINEERING SPECIALISTS.

LONDON OFFICE: 38, VICTORIA STREET, WESTMINSTER, S.W. 1.
TELEPHONE–3190 VIC, LONDON.
TELEGRAMS: "VILVALLE, LONDON."

TELEPHONE NOS. 20181 & 20182 LEEDS.
TELEGRAMS: "RIVETTER LEEDS."

ON ADMIRALTY AND WAR OFFICE LISTS.

PRESSES
FOR
ALL PURPOSES.
FORGING
FLANGING
WHEELS
SLEEPERS
CELLULOID
CONCRETE
COTTON
COAL
PEAT
PAPER
TEA
ETC.

RIVETTERS
OF ALL SIZES.
MANUFACTURERS
AND
EXPORTERS
OF
MACHINERY
TO
ALL PARTS OF
THE WORLD.

MAKERS OF
PLATE BENDING
ROLLS
PUNCHES
SHEARS
CRANES
ETC.

IN STOCK
FIXED HYDRAULIC RIVETTER 17' 6" GAP
3 POWERS 33, 67 AND 100 TONS.

YATES & THOM, LTD.,

Telegraphic Address—Yates, Blackburn.
Telephone Nos.—4224 (4 lines).
Codes—A.B.C. and A 1.

Canal Works,
BLACKBURN.

Winding Engines.
Air Compressors.
Electric Haulage Plants.

LANCASHIRE and CORNISH BOILERS.

SEMI-CONICAL WINDING DRUM.

Blowing Engines.
Rolling Mill Engines.
Heavy Pumping Plants.

MILL GEARING in all its BRANCHES.

BOILER FITTINGS.
SETTING ACCESSORIES.
STORAGE TANKS.

ECONOMISERS.
PIPING INSTALLATIONS.
SUPERHEATERS.

HIGH-CLASS ENGINES WITH CORLISS OR DROP VALVES. 8461

"The Theory and Practice of PLATE CLUTCHES."

We have lately produced a brochure on the attractive proposition of power transmission by plate clutches.

It publishes for the first time information of special interest to engineers in this the transition period.

It will be sent post free on receipt of a request.

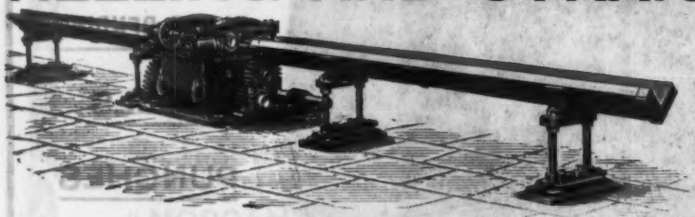
FERODO LTD CHAPEL-EN-LE-FRITH. 8602

Contractors to the War Office and Admiralty, London General Omnibus Company, and Underground Electric Railways of London and Paris.

Depôts at London, Birmingham, Bristol, Cardiff, Coventry, Edinburgh, Glasgow, Liverpool, Manchester, Newcastle and Swansea.

REELING AND STRAIGHTENING MACHINES,

FOR TUBES, BARS, &c.



SAMUEL PLATT, LD., WEDNESBURY. 8367

Agents for Colonies and Foreign Countries:—Alfred Herbert Limited, 13, British India Street, Calcutta; Alfred Herbert Limited, 14 Yamashita-Cho, Yokohama; Société Anonyme Belge Alfred Herbert, 35, Rue de Lacken, Brussels; Societa Anonima Italiana Alfred Herbert, 42, Via Cajazzo, Milan; Alfred Herbert Limited, Sydney, N.S.W.

Tensile Strength 30 tons.

Non-Erosive

Manganese Bronze.

25% Elongation.

WE HAVE NOT HAD A BROKEN PROPELLER IN 25 YEARS.

MANGANESE AND SILICON COPPER.
PHOSPHOR BRONZE, TIN & COPPER.
ANTI-FRICTION METALS, COPPER AND NICKEL HARDENED.
BABBITTS AND PLASTIC METALS.
CASTINGS ANY SIZE OR WEIGHT.

Telephone:—Potteries 304 (2 lines).

OAK BRAND B N

Telegrams:—"Bronze."

BILLINGTON & NEWTON, LTD., LONGPORT, STAFFS. 8318

HUMPHREYS & GLASGOW, Ltd.,

38, VICTORIA STREET, LONDON, S.W.

BLUE WATER GAS

659 SETS of HUMPHREYS-GLASGOW PLANT

have been (and are being) installed with a capacity of over 397,500,000 cubic ft. of Water-Gas per diem. Including the work of their American colleagues, 1599 sets have been constructed with a total daily capacity of over 1,140,750,000 cub. ft.

Chemical Composition. Volumes.	
H_2	50.0
CO	42.0
CO_2	4.0
CH_4, H_2S	1.0
N_2	3.0
	100.0

Physical Properties.	
Sp. Gr.	.54
Sp. Heat B.tu. per lb.	.449
Cal. Power B.tu. per c.f.	309
Flame Temp.	3382°

8910

Steam Power Plant

For Land and Marine Purposes.

Brotherhood Steam Engines and Turbines offer dependable, low-cost power, and embody the specialised skill of many years' experience.

STEAM TURBINES

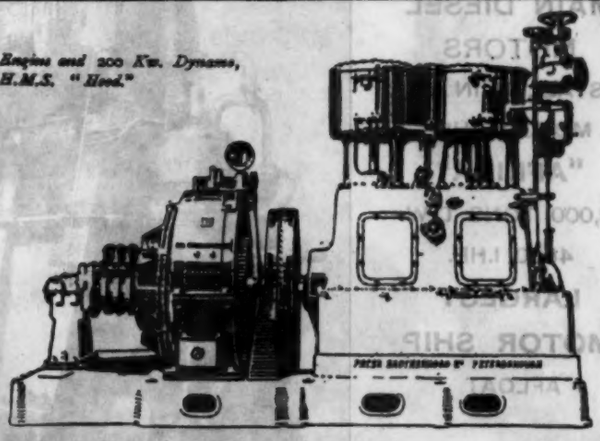
Impulse Type, up to 1000 HP. Special types for back pressure work. Automatic bearing lubrication by ring or pump according to size.

Simple and Compound STEAM ENGINES

for all purposes, thoroughly reliable in performance and requiring the minimum of attention. Forced lubrication.

Write for Catalogue.

Engine and 200 Kw. Dynamo, H.M.S. "Hood."



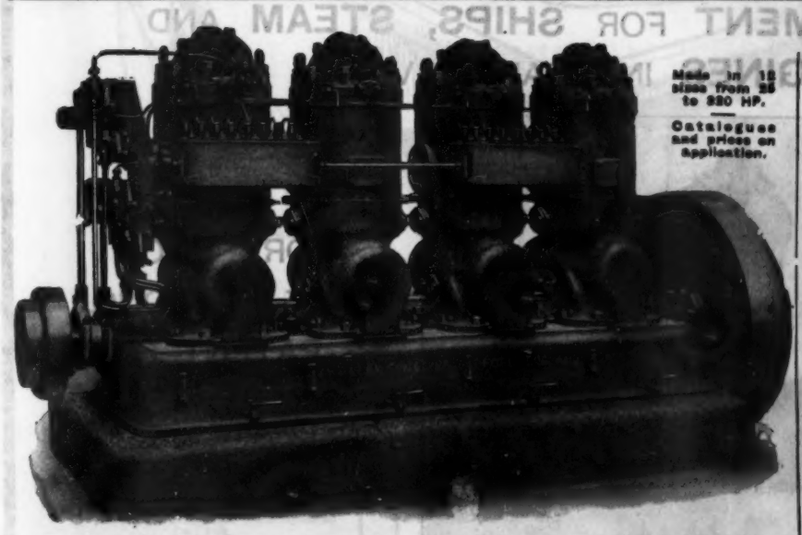
PETER BROTHERHOOD LTD

Head Office & Works

PETERBOROUGH · ENGLAND

BRANCHES:— LONDON · MANCHESTER · NEWCASTLE-ON-TYNE BIRMINGHAM AND GLASGOW.

8598



Made in 18 sizes from 25 to 930 HP.

Catalogues and prices on application.

THE "ALLEN" Heavy Fuel Oil Engine

THE "ALLEN" Heavy Fuel 2-stroke Oil Engine is simple in construction and simple to operate. For an internal Combustion Engine it has a minimum number of working parts, rendering it especially suitable for use where skilled engineers are unobtainable.

Runs equally well with Crude Oil, Refined Petroleum, Shale, or low grade and cheap oils.

Special Features—

- Great Flexibility.
- Low Fuel Consumption.
- Small Space Required.
- Length of Life.
- Forced Lubrication to Moving Parts.
- Perfect Combustion.
- Quick Starting.
- Simplicity in Use.
- Freedom from Deposit in Cylinder.
- Accessibility to Working Parts.
- No Compressed Air used for Fuel Injection.

W. H. ALLEN, SONS & CO., LTD.,

Queens Engineering Works, ∴ ∴ BEDFORD, England.

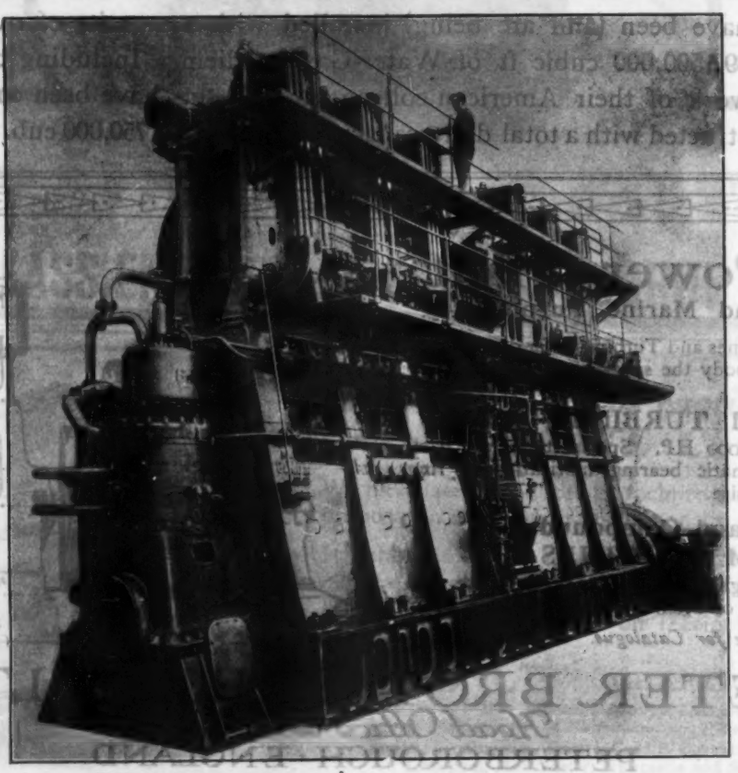
8731

BURMEISTER & WAIN, LTD.

ENGINEERS AND SHIPBUILDERS, COPENHAGEN, DENMARK.

BUILDERS OF LARGE SEAGOING DIESEL MOTOR SHIPS,

CARGO VESSELS AND LINERS UP TO 600 FT.

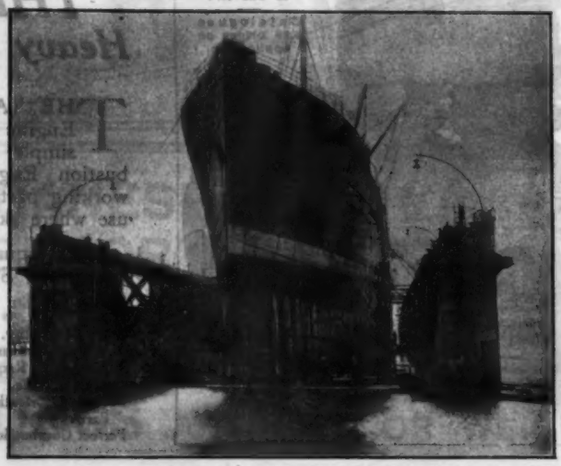


ONE OF THE TWIN MAIN DIESEL MOTORS INSTALLED IN THE MOTOR SHIP "AFRIKA" 13,000 TONS D.W. 4500 I.HP. LARGEST MOTOR SHIP AFLOAT.

A SIMILAR SET OF DIESEL MOTORS DELIVERED TO THE UNITED STATES SHIPPING BOARD EMERGENCY FLEET CORPORATION.

LARGEST WORKS FOR BUILDING MARINE AND STATIONARY **DIESEL MOTORS.** LARGEST, BEST EQUIPPED & QUICKEST **REPAIR ESTABLISHMENT** FOR **SHIPS, STEAM** AND **DIESEL ENGINES** IN SCANDINAVIA.

100 TONS STATIONARY HAMMERHEAD CRANE.



DRY DOCK 475 FT. LONG. 3 PATENT SLIPS 300 FT. LONG.

8183

FLOATING DOCK, 11,500 TONS CAPACITY.

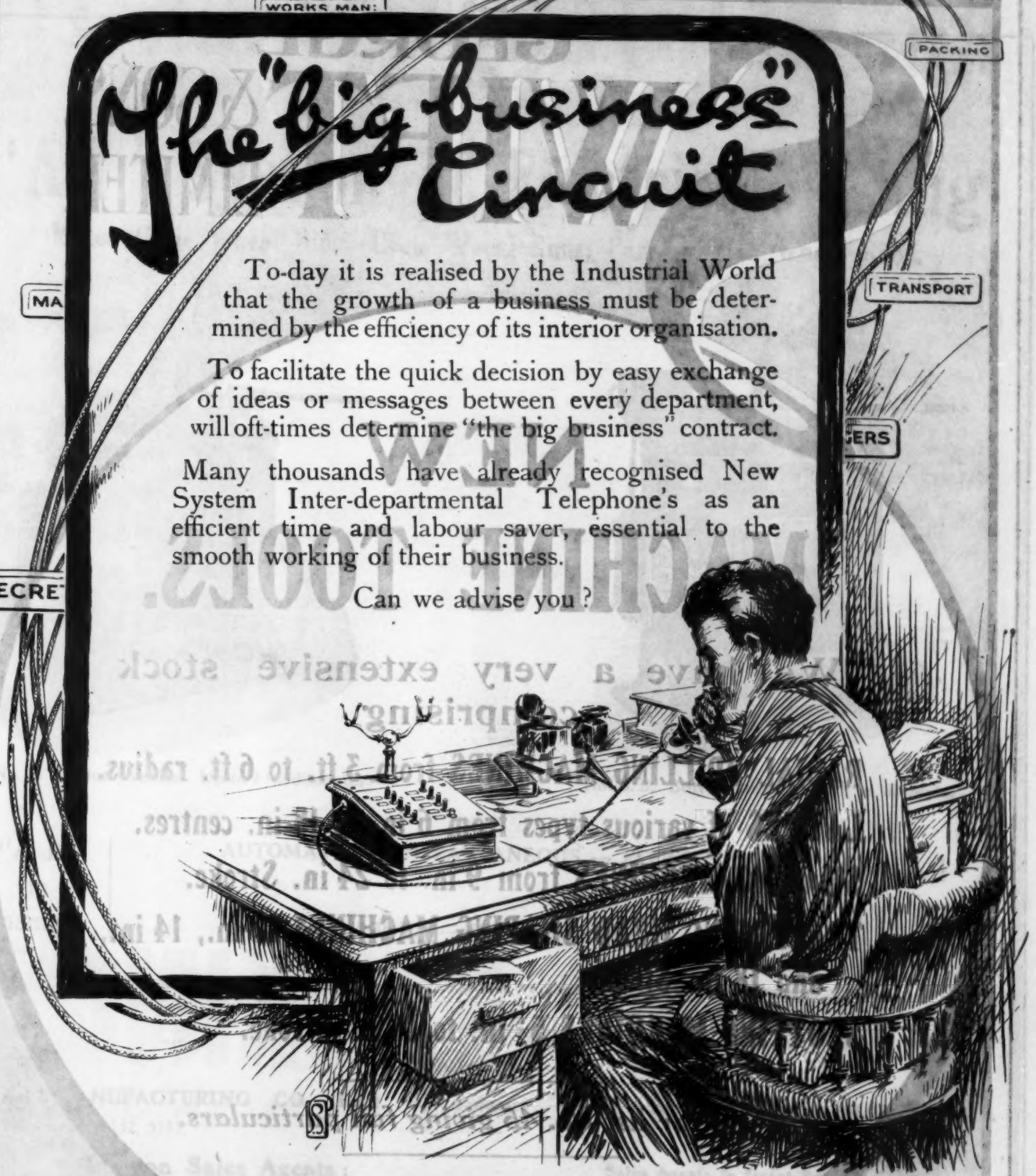
The "big business" Circuit

To-day it is realised by the Industrial World that the growth of a business must be determined by the efficiency of its interior organisation.

To facilitate the quick decision by easy exchange of ideas or messages between every department, will oft-times determine "the big business" contract.

Many thousands have already recognised New System Inter-departmental Telephone's as an efficient time and labour saver, essential to the smooth working of their business.

Can we advise you?



LONDON: The London Telephone (New System) Co., Ltd., Donington House, Norfolk Street, Strand, W.C. 2.

BIRMINGHAM: The Birmingham Telephone (New System) Co., Ltd., Lincoln's Inn, 114, Corporation Street, Birmingham.

MANCHESTER: The Lancashire and Yorkshire Private Telephone Co., Ltd., 28, Queen Street, Albert Square, Manchester.

8291

LIVERPOOL: The Liverpool Telephone (New System) Co., Ltd., 16, Rodney Street, Liverpool.

LEEDS: The Leeds Private Telephone (New System) Co., Ltd., 2, Bastinghall Square, Leeds.

SHEFFIELD: The Sheffield Telephone (New System) Co., Ltd., 99-105, Pinstone Street, Sheffield.

SCOTLAND: The Caledonian Telephone (New System) Co., Ltd., 62-64, Robertson Street, Glasgow.

CARDIFF: The South Wales and Monmouthshire Telephone (New System) Co., Ltd., 15, Charles Street, Cardiff.

BRISTOL: The Bristol and West of England Telephone (New System) Co., Ltd., 35, Broad Street, Bristol.

IRELAND: The Irish Telephone (New System) Co., Ltd., 16, Donegall Square South, Belfast.

NEWCASTLE-ON-TYNE: The Newcastle Telephone (New System) Co., Ltd., Central Exchange Buildings, 50, Grainger Street, Newcastle-on-Tyne.

GEORGE SWIFT & SONS, LIMITED.

NEW MACHINE TOOLS.

We have a very extensive stock comprising

RADIAL DRILLING MACHINES from 3 ft. to 6 ft. radius.

LATHES of various types from 6 in. to 15 in. centres.

SHAPING MACHINES from 9 in. to 24 in. Stroke.

TRAVERSING HEAD SHAPING MACHINES 12 in., 14 in., and 18 in. Stroke.

SLOTTING MACHINES 5½ in. to 14 in. Stroke.

8448

Write for list No. 45 giving full particulars.

CLAREMONT IRON WORKS

HALIFAX

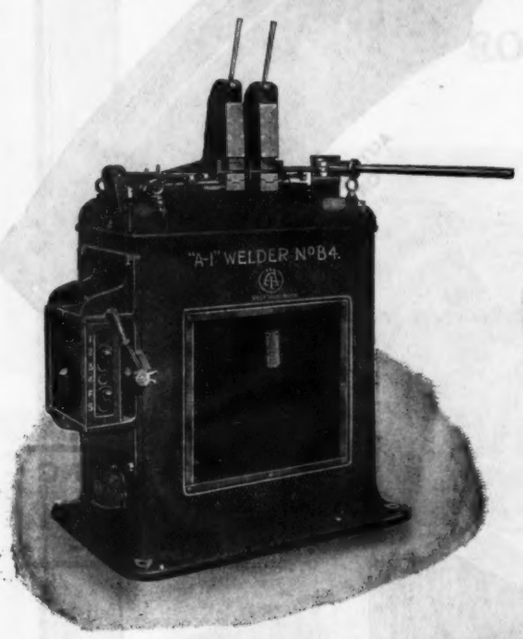
ENGLAND

TELEGRAMS: "SWIFTLY HALIFAX"

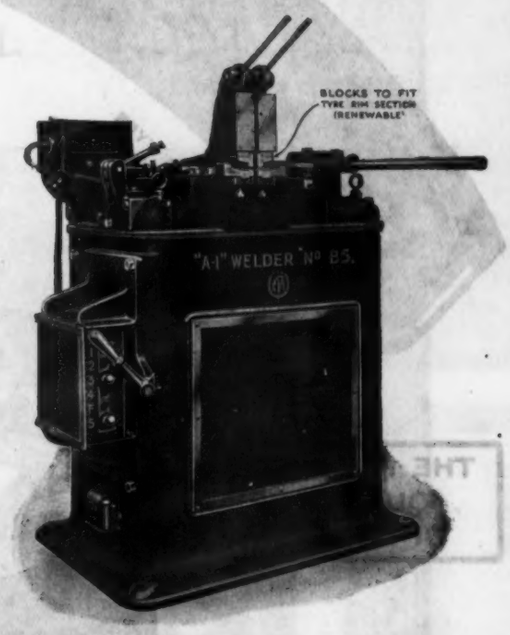
TELEPHONE 497 HALIFAX

"A-I" System of Electric Welding

Motor Cycle Wheel Rims, Cycle Wheel Rims, Perambulator Wheel Rims.



No. B. 4. Butt Welder. Up to $\frac{5}{8}$ in. diameter.



No. B. 5. Butt Welder. Up to $\frac{3}{4}$ in. diameter.

"A-I" in name. | AUTOMATIC — INSTANTANEOUS — EFFICIENT. GIRL LABOUR — PERFECT RESULTS. | A.1 in quality.

Especially simple to adjust to accommodate various kinds and shapes of work.

Made by

A-I MANUFACTURING CO. (Dept. D), Industry Works, Sunbridge Road, BRADFORD.
Telephones: 5152, 5153. Telegrams: "Patterns," Bradford.

London Sales Agents:

BUCKLEY, SAUNDERS & Co., Ltd. (Dept. D)
Abbey Buildings, 8, Princes St., Westminster, S.W. 1.
Telephone—Victoria 792. Telegrams—"Aipaternis, Parl." London.

Sole Selling Agents in Foreign Countries.

8400

Sales Agents in Great Britain:

PERKIN & CO., Ltd. (Dept. D)
Junction Works, Whitehall Road, LEEDS.
Telephone—26805. Telegrams—"Perco," Leeds.

R. G. KYTE (Dept. D)
Heathfield, Park Street, Bridgend, S. Wales.
Telephone—98 Bridgend.

"LION" PACKINGS

AUTOMATIC IN ACTION.

THE PACKING QUALITY OF FIBRE.

THE WEARING QUALITY OF METAL

BLOCK TYPE FOR STEAM.

THE KING OF PACKINGS

REFUSE ALL IMITATIONS. **LOOK FOR THE THIN RED LINE.**

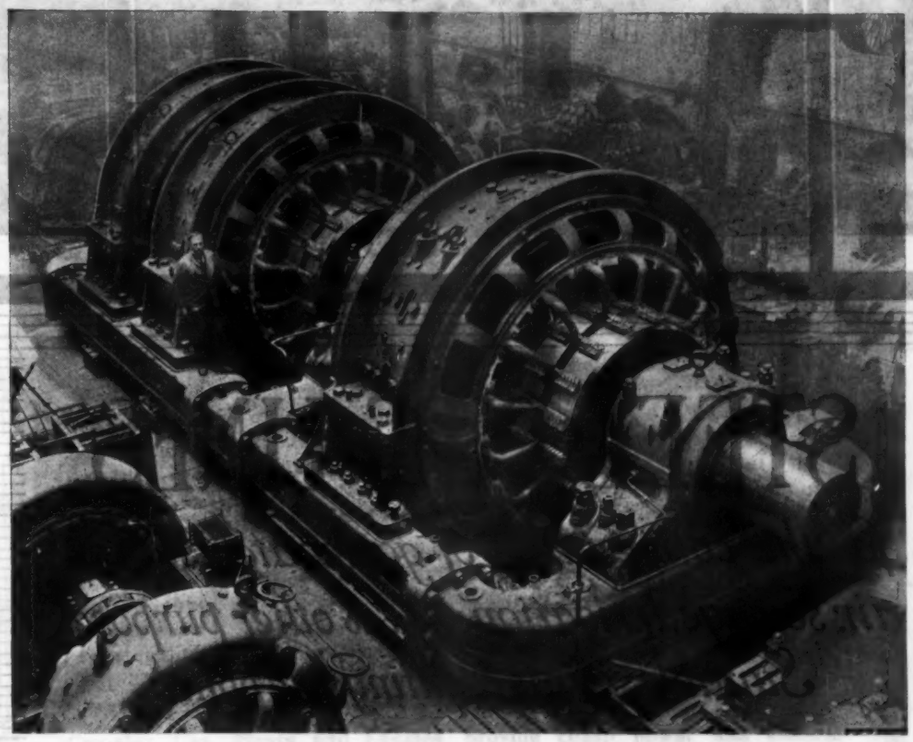
WRITE FOR CATALOGUE NO. 3 TO THE PACKING EXPERTS AND SPECIALISTS.

JAMES WALKER & Co LTD LION WORKS, GARFORD STREET, WEST INDIA DOCK RD., LONDON, E. 14.

TELEPHONE—EAST 4253 (3 LINES). TELEGRAMS—"LIONCELLE, POP, LONDON."

The ENGLISH ELECTRIC Company Limited.

ROLLING MILL MOTORS



19,000 H.P. REVERSING MILL MOTOR ± 0/140 R.P.M.
DRIVING 34 in. ROUGHING AND FINISHING MILL.

5084

Head Office: QUEEN'S HOUSE, KINGSWAY, W.C.2.
Telephone: HOLBORN 830. Telegrams: "ENELECTICO, WESTCENT, LONDON."

WORKS:
DICK, KERR WORKS, PRESTON. PHŒNIX WORKS, BRADFORD.
ORDNANCE WORKS, COVENTRY. SIEMENS WORKS, STAFFORD.
WILLANS WORKS, RUGBY.

BRANCHES IN PRINCIPAL TOWNS AT HOME AND ABROAD.

STEEL·PIPE·LINES

for the conveyance of gas, water, steam, air, sewage, irrigation, oil, and other purposes

Suitable joints & fittings supplied.

Tubular Steel Electric Light Standards ✣ Tramway & Telegraph Poles
Transmission Towers ✣ Masts &c ✣ Steel Plates ✣ Steel Castings
Ashford's Patent Tube Well Strainers.

8136

CATALOGUES FREE ON APPLICATION.

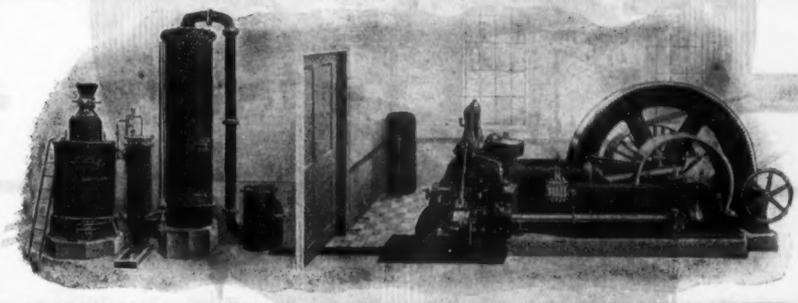
STEWARTS and LLOYDS, Ltd

GLASGOW·BIRMINGHAM·LONDON LIVERPOOL·MANCHESTER·CARDIFF·LEEDS

L&L

CROSSLEY

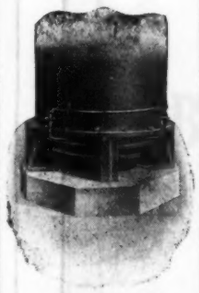
SUCTION GAS PLANTS



Crossley Suction Gas Plant and Engine for Anthracite, Coke, and Charcoal.

CROSSLEY SUCTION GAS PLANTS

represent the highest development in gas plant design, and combined with Crossley Engines form a power unit that cannot be excelled for economy and reliability.



Open Hearth Stepped Firegrate.

The open hearth stepped grate gives accessibility to the fire which can be kept free from clinker, thus ensuring gas of even quality.

Their features are open hearth firegrate, patent feeding hopping and charging valve, external vapouriser, exhaust starting fan and scientific portioning of parts which give distinct advantages in economy, reliability and simplicity of operation.

Two main types are made—

(a) for using anthracite, coke, and charcoal.

(b) for refuse fuels, such as all kinds of waste wood, spent tan, mealie cobs, olive refuse, cotton seed refuse, cocoa-nut shells, rubber seeds, rice husks, &c.

The patent fuel hopper prevents the admission of air into the generator when fresh fuel is supplied, and maintains an even depth of fuel.

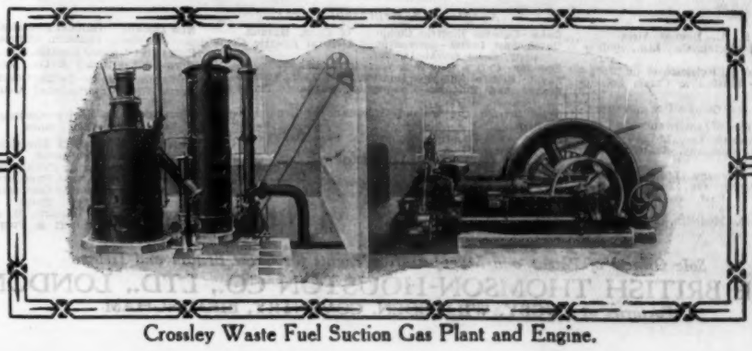
Feeding Hopper and Charging Valve.

Crossley Gas Plants and Engines provide cheap power and electric current for all purposes.

CROSSLEY BROTHERS, LTD.

OPENSHAW **MANCHESTER.**

MAKERS OF THE HIGHEST GRADE GAS PLANTS AND ENGINES IN THE WORLD.



Crossley Waste Fuel Suction Gas Plant and Engine.

C 4

PASSENGER SERVICE ON CROWDED STREETS

WITHOUT electricity the passenger service in areas of crowded traffic would be far more expensive, if not impossible.

Since the first electrification of the horse-car, nearly forty years ago, the "G-E" symbol has stood for constant improvement in street railway equipment.

The modern tram-car, with G-E equipment, moves steadily through traffic congestions, maintains schedules on busy streets, climbs steep grades and stands up under excessive overloads under all weather conditions. In multiple units, it hurries suburban passengers to and from industrial and shopping centres.

General Electric engineers have developed and standardized complete railway equipment, including every piece of apparatus necessary for an entire system, thoroughly up-to-date, from the turbo-generators of the power station to the control apparatus, line material, sub-stations, and car equipments.

A list showing where G-E street railway equipment is used would include almost every large city in the world.

Agents and representatives of the International General Electric Company, Inc., listed below, are in close touch with the very latest developments in modern street railway systems.

Look for this mark of leadership in electrical development and manufacture.

International General Electric Company, Inc.

NEW YORK 120 BROADWAY — LONDON 83 CANNON ST.

SCHENECTADY, N. Y.

Distributors for the General Electric Company outside of the United States

Agents and Representatives:

Argentina—General Electric, S. A., Buenos Aires.
Australia—Australian General Electric Co., Ltd., Sydney and Melbourne.
Belgium and Colonies—Société d'Electricité et de Mecanique Procedes Thomson-Houston & Carels Société Anonyme, Brussels.
Bolivia—International Machinery Co., La Paz and Oruro.
Brazil—General Electric, S. A., Rio de Janeiro and São Paulo.
Canada—Canadian General Electric Co., Ltd., Toronto.
Chile—International Machinery Company, Santiago, Antofagasta and Valparaiso.
China—Andersen, Meyer and Company, Ltd., Shanghai. International General Electric Co., Inc., (General Representatives of the Far East, excluding China and Japan), Shanghai.
Colombia—Wemelhoeft & Poor, Medellin, Barranquilla and Bogota.
Cuba—General Electric Company of Cuba, Havana.
Dutch East Indies—International General Electric Company, Inc., Soerabaia, Java.
Ecuador—Carlos Cordovez, Guayaquil and Quito.
Egypt—British Thomson-Houston Co., Ltd., Cairo.
France and Colonies—Compagnie Française Thomson-Houston, Paris.
Great Britain and Ireland—International General Electric Co., Inc., London.
Greece and Colonies—Compagnie Française Thomson-Houston, Paris, France.
India—International General Electric Co., Inc., Calcutta and Bombay.
Italy and Colonies—Franco Tosi Società Anonima, Milan.
Japan—Shibaura Engineering Works, Tokyo; Tokio Electric Company, Ltd., Kawasaki.
Mexico—Mexican General Electric Co., City of Mexico and Guadalajara.
New Zealand—National Electrical & Engineering Co., Ltd., Auckland, Dunedin, Christchurch and Wellington.
Paraguay—General Electric, S. A., Buenos Aires, Argentina.
Peru—W. R. Grace & Co., Lima.
Philippine Islands—Pacific Commercial Company, Manila.
Porto Rico—International General Electric Co., Inc., San Juan.
Portugal and Colonies—Compagnie Française Thomson-Houston, Paris, France.
Russia—Wsesobshtchaia Electricheskaia Kompania, Petrograd and Vladivostok.
South Africa—South African General Electric Co., Ltd., Johannesburg and Capetown.
Spain and Colonies—Compagnie Française Thomson-Houston, Madrid, Spain.
Uruguay—General Electric, S. A., Montevideo.
Venezuela—Wemelhoeft & Poor, Caracas.

Sole Owners of Patent and Manufacturing Rights for Great Britain and Ireland

THE BRITISH THOMSON-HOUSTON CO., LTD., LONDON

Factories at RUGBY, WILLESDEN, COVENTRY, BIRMINGHAM

8867

32-34

BUILDERS OF SPECIALIZED MACHINE TOOLS.

A. B. M. T. M.

The survival of the fittest is a natural physical law.

That is why you find BUTLER Reciprocating Machine Tools working with perfect satisfaction in most of the principal machine shops in the country, while other tools of (alleged) similar capacity have been relegated to lighter jobs.

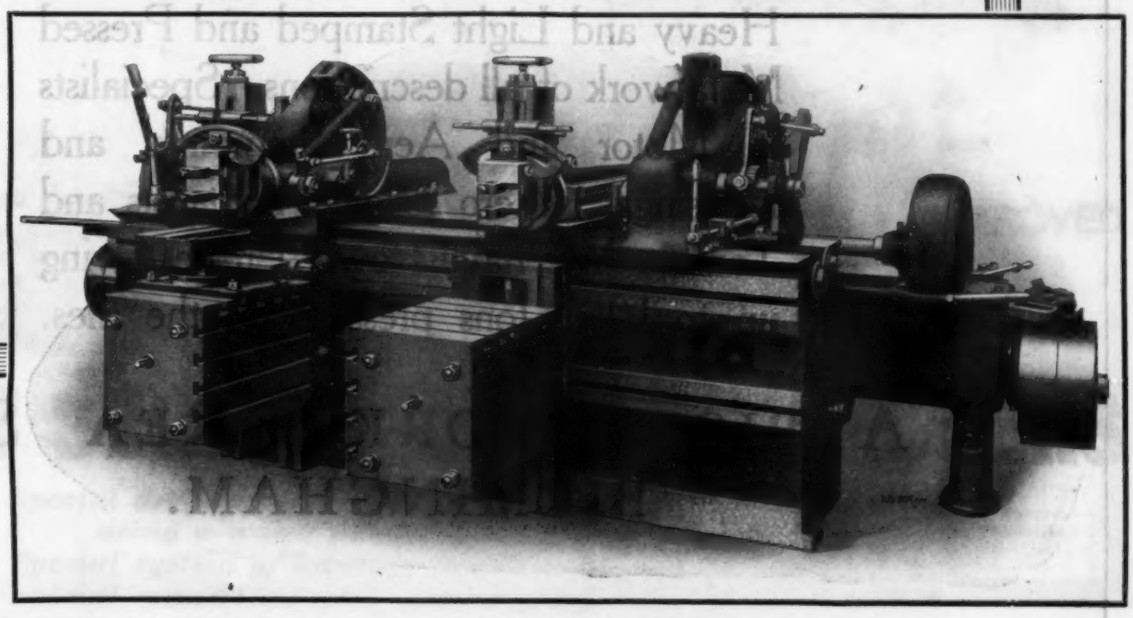
Look at this Butler Double Traverse Head Shaper. Have you considered it on your job. If not, write us and one of our tool men shall investigate the probability of reducing some of your costs.

ASSOCIATED

BRITISH MACHINE TOOL MAKERS, LTD.

17, GROSVENOR GARDENS, S.W. 1.

Branches at Birmingham, Bristol, Glasgow, Leeds, Manchester, Newcastle-on-Tyne, Paris, Brussels, Rotterdam, Milan, Madrid, Buenos Ayres, and Delhi.



8000

D X N TRADE MARK

DIXON'S

D X N TRADE MARK

"Ticonderoga" Pure Flake

LUBRICATING GRAPHITE

CHEMICAL ANALYSIS :—A chemical analysis is not the best test for graphite that is to be used as a lubricant. It is the physical characteristics, such as structure, size and shape of particles, cohesiveness, unctiousness, and kind of impurity, that bear the really important relation to its lubricating value—not the mere high percentage of carbon. Some of the purest grades of graphite are unfit for lubrication. The only way to purchase graphite is by its trade designation, for no chemical specification has ever been written that will ensure getting good lubricating graphite. That is why we sell graphite for *what it will do*, and not for what it is chemically.

Insist on getting "DIXON'S."

Don't accept "just as good"; there isn't any.

C. R. AVERILL, Sole Agent for United Kingdom (except pencil products), **28, Victoria Street, London, S.W. 1.**

Telegrams: Crucigraph, Vic., London. Telephone: Victoria 1754.

DIXON'S GRAPHITE PRODUCTS

FISHER & LUDLOW LTD.

Telephones - - - 413 and 414 MIDLAND.

Heavy and Light Stamped and Pressed Metalwork of all descriptions. Specialists in Motor and Aero Stampings and Pressings. Aero Engine Exhausts and Tanks. We have Power Presses giving up to 1000 tons pressure on the dies.

ALBION WORKS, REA ST.
BIRMINGHAM.

8594

Manufactured by B.S.A. Tools Limited, Birmingham.

is behind every B.S.A. Twist Drill

The valuable knowledge of drill requirements accumulated over this long period is turned to the fullest advantage in the production of B.S.A. Twist Drills.

It is allied to scientific methods, modern machinery, and the well known B.S.A. system of inspection at every stage of manufacture, and thus ensures every B.S.A. Drill being absolutely uniform in quality. The final test before the drills leave the factory is on a special hydraulic machine. A representative drill from each batch is tested, and if it fails to withstand a certain torque and end pressure (far in excess of average strain), the entire batch is at once rejected.

Write for prices and particulars to the Selling Agents

Also at BIRMINGHAM, MANCHESTER, GLASGOW.

6397

Burton Griffiths & Co., Ltd.

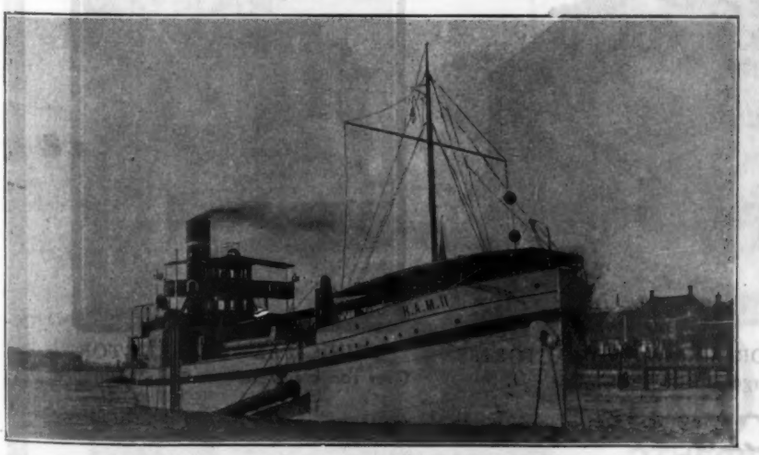
Ludgate Square, Ludgate Hill, London, E.C. 4.

N.V. L. SMIT & ZOON'S SCHEEPS-EN WERKTUIGBOUW,

SHIPBUILDERS AND ENGINEERS,

KINDERDIJK (near ROTTERDAM), HOLLAND.

Telegrams—SMITSZOON, KINDERDIJK.



Dredging Plant.

LATEST & MOST IMPROVED TYPES.

PATENT SUCTION HOPPER DREDGERS

With: *Special arrangement to discharge Hopper by suction without using a water pump.*

With: *Special system of hauling inboard the suction-tube.*

With: *Special connection with shore-piping.*

1497

THE ELECTRIC CONSTRUCTION Co LTD.

TELEGRAMS:
"CONCORDANCE AVE." LONDON.
"ELECTRIC." WHAMPTON.

TELEPHONES:
10920 CENTRAL. 2671. LONDON WALL.
75 & 430. WHAMPTON.

LECTRICAL
MACHINES
OF EVERY
DESCRIPTION.

ONVERTERS.
DYNAMOS.
MOTORS.
ALTERNATORS.
SWITCHGEAR.

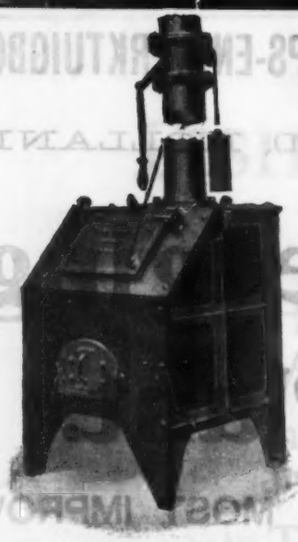
HEAD OFFICE:
DASHWOOD HOUSE,
9, NEW BROAD ST,
LONDON E.C.2.

SOLE AGENT
LANCASHIRE & YORKSHIRE.
MR R. MILLETT.
30. CROSS ST MANCHESTER.

WORKS
BUSHBURY, WOLVERHAMPTON.

8379

A MELDRUM DESTRUCTOR



TRADE DESTRUCTOR.
Sizes from 30 lbs. to 5 cwt. per hour.

DESTRUCTOR FOR CAMPS AND FACTORIES
having large quantities of refuse.

MUNICIPAL DESTRUCTOR.
Over 100 complete installations supplied.

FOR EVERY SERVICE.

If you have any combustible refuse or trade residue, we can probably instal a plant which will not only convert the refuse into a hard clinker, but utilise the heat generated for steam raising, boiling water, or drying. At a large tannery we are generating sufficient steam from the spent tan to run the tannery.

Send us, at once, some data as to the nature and amount of the refuse and we will at once advise you.

7283

Telegrams: "Meldrum, Altrincham."
Telephone: 181 Altrincham.

MELDRUMS LTD., Timperley, Manchester.

LONDON OFFICE: 108, Victoria Street, Westminster, S.W.1.

Steel Castings!

WE are laid out for the production of electric steel castings of the highest quality for general engineering work.

ALLIED STEEL MAKERS & FOUNDERS, LIMITED.

WORKS:

Braintree Castings Co. BRAINTREE, ESSEX.
The National Steel Foundry (1914), Ltd. LEVEN, FIFE.
Thwaites Bros., Ltd. BRADFORD, YORKS.

BRANCH OFFICES:

COVENTRY: 29, Hertford Street.
NEWCASTLE-ON-TYNE: 3, Saville Chambers, North St., Saville Row.

ENQUIRIES TO HEAD OFFICE:

CENTRAL HOUSE, KINGSWAY, LONDON, W.C. 2.

9.139

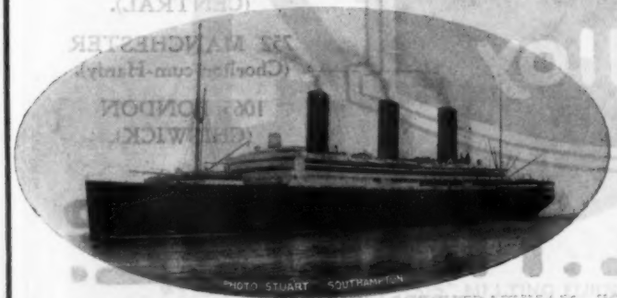
MUMFORD'S PATENT AUTOMATIC FEED WATER REGULATOR

H.M.S "HOOD."

SIMPLE
RELIABLE
EFFICIENT
FOR
SEA OR LAND.

THE REGULATOR
WITH AN
ESTABLISHED REPUTATION
SUPPLIED TO
BOILERS OF OVER 10,500,000 I.H.P.

THESE NOTEWORTHY SHIPS



Cunard Line R.M.S. "IMPERATOR."

AND OVER **500** OTHERS ARE FITTED WITH IT.

8374

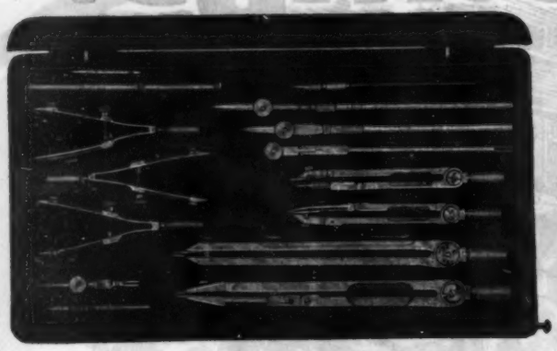
P. & O. Line R.M.S. "CAP POLONIO."

A. G. MUMFORD, LTD., ENGINEERS, COLCHESTER.

HALDEN

NEW PATTERN BRITISH MACHINE-MADE

Drawing Instruments.



No. 1170 CASE.

Finest Quality and Finish.

BRITISH THROUGHOUT.

No. 1100 HALF-SET.

These instruments were first manufactured at the request of a Government Departmenta Committee to meet the demands of the Ministry of Munitions.

The design has lately been considerably improved, and our extensive modern plant is now turning out large quantities.

They are supplied loose or in a variety of Cases to suit either the Technical Student or the fully qualified Draughtsman.

Fully Illustrated List and Quotations on request.

Foreign Agencies.

Australia—
A. Brydges-Todd,
Aberdeen House,
528, Collins Street,
MELBOURNE.

South Africa—
The Griffin Engineering Co. Ltd.,
94, Main Street,
JOHANNESBURG.

France—
A. Deloffre,
Palais de la Bourse,
LILLE.

Argentine—
E. F. Bideleux,
Calle Chacabuco, 443,
BUENOS AIRES.

8157

J. HALDEN & CO., Ltd. (Dept. A 5), 8, Albert Square, Manchester.

Depots: LONDON, NEWCASTLE-ON-TYNE, BIRMINGHAM, GLASGOW and LEEDS.

CASTINGS

Telegrams:
"HALEFO, TIPTON."
"FAIRMAN, GLASGOW."
"MALSTEEL, MANCHESTER."
"UMALSTEELO, CHISK, LONDON."
Codes: A.B.C. 5th Edition, Marconi International.

Malleable Iron & Steel Alloy

Telephones:
72 TIPTON (PTE. EX.).
210 GLASGOW (CENTRAL).
752 MANCHESTER (Chorlton-cum-Hardy).
1065 LONDON (CHISWICK).

THOMAS L. HALE LTD.

"MEMBERS OF THE NATIONAL UNION OF MANUFACTURERS (INC.)."

DUDLEY PORT, TIPTON, STAFFS.

8455

SUPPLIERS TO H.M. ADMIRALTY, WAR OFFICE, MINISTRY OF MUNITIONS, LEADING RAILWAYS, SHIPBUILDERS, MOTOR CAR MANUFACTURERS, ENGINEERS, Etc., Etc.

J.H.RICHARDS & Co. LIMITED

REGISTERED J.RICHARDS P.M. TRADE MARK

Sole Manufacturers of J. RICHARDS' PLASTIC METAL

We have supplied more CHILL CAST SOLID WHITE METAL BEARINGS for INTERNAL COMBUSTION ENGINES During the last 8 years than any other BRITISH MANUFACTURER

Telephone: EAST – 800. Telegrams "WESTMINSTER" B'HAM

Quotations on CHILL CAST BEARINGS *Application*

MADE IN

J. RICHARDS PLASTIC METAL

BY OUR OWN PERFECTED PROCESS OF CASTING IN CHILLS UNDER PRESSURE AT LOW TEMPERATURE.

GUARANTEED ACCURACY - 001"

THESE BEARINGS REQUIRE NO MACHINING AND ARE READY FOR THE ERECTORS.

WE WERE THE PIONEERS IN THIS COUNTRY OF THIS TYPE OF BEARING. DURING THE EXPERIMENTAL PERIOD WE GAINED VALUABLE INFORMATION WHICH IS EMBODIED IN OUR PROCESS & ENABLES US TO GUARANTEE THESE BEARINGS TO BE FREE FROM BLOW HOLES & INTERNAL STRESSES.

J.H.RICHARDS & Co. LIMITED

Cato St. North, BIRMINGHAM

WRIGHT-MORGAN 'LIP-AXIS" MELTING FURNACE, OIL-FIRED. TILTED FOR POURING

FURNACES

FOR

METAL MELTING

Wright-Morgan "Lip-Axis" Crucible Furnaces are strongly recommended for melting Copper, Brass, Gun-metal, Aluminium, etc. High temperatures are attained. All operations are easily carried out under complete control, and melting efficiency is provided with utmost economy in fuel consumption and labour cost. Also made for firing with Town-Gas, Coke, or Oil.

MADE UNDER THE COMBINED PATENTS OF THE MORGAN CRUCIBLE CO. LTD. & JOHN WRIGHT & CO.

Full particulars given on request by the Makers:

JOHN WRIGHT & CO.,

ESSEX WORKS, ASTON, BIRMINGHAM. 8866

Telegrams: "Eureka," Birmingham. Telephone: Central 2169 (5 lines).

DROP FORGINGS

FOR THE ENGINEERING TRADES MADE IN

STEELS to any analysis, special attention being paid to the heating and working of Carbon, Nickel, Nickel Chrome, Chromium, Chrome Vanadium, and other Alloy Steels.

HEAT TREATMENT carried out under the direct supervision of our laboratory to meet all Engineering Standards Committee, Air Board, Admiralty, War Office and other Specifications and Tests.

SEND YOUR ENQUIRIES TO—

SMETHWICK STAMPING CO.

(Proprietors: Valor Co., Ltd.) Bridge Street, Smethwick. 8830

GIBBONS BROS., LTD.,

Telegrams:—
"GIBBONS, LOWER GORNAL."

DUDLEY.

Telephone:—10, DUDLEY.

Contractors to ADMIRALTY and WAR OFFICE.

Patentees and Builders

OF

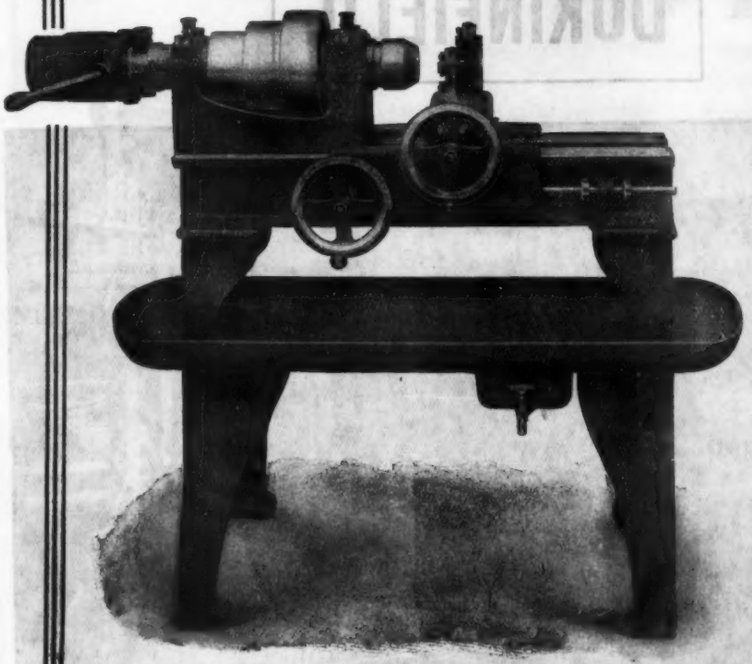
REGENERATIVE MUFFLES & FURNACES

FOR ALL

ENGINEERING WORK.

8535

CAPSTAN LATHES
AND
ACCESSORIES



5, 6 & 7in. CENTRE SHAVING
OR
2nd OPERATION LATHES.

CAPACITY: $\frac{3}{4}$, $1\frac{1}{4}$, and $1\frac{3}{8}$ in.
THROUGH AUTO-CHUCK.

Catalogue and Particulars on Request.

Telegrams: LATHES, BIRMINGHAM.
Telephone: CENTRAL 6373 (3 lines). 8265

CHARLES TAYLOR (BIRMM.) LTD., BARTHOLOMEW SQUARE, **BIRMINGHAM.**

BETTER LIGHTING
MAKES FOR
INCREASED PRODUCTION.

USE **SCEANDO** 'HALF WATT' TYPE
DRAWN WIRE **LAMPS.**

FROM ALL ELECTRICIANS, IRONMONGERS, ETC.

Manufactured by
CROWTHER & OSBORN, LTD.
7, Blackfriars Street, SALFORD,
MANCHESTER.

Lamp Works - - BOLLINGTON, MACCLESFIELD.
Glass Works - - - SALFORD and BREDBURY.

Telegrams—CRANDOS. 9019 Telephone—7207 CITY.

STEAM TURBINES.

TURBO BLOWERS.

TURBO PUMPS.

SURFACE CONDENSING PLANT.

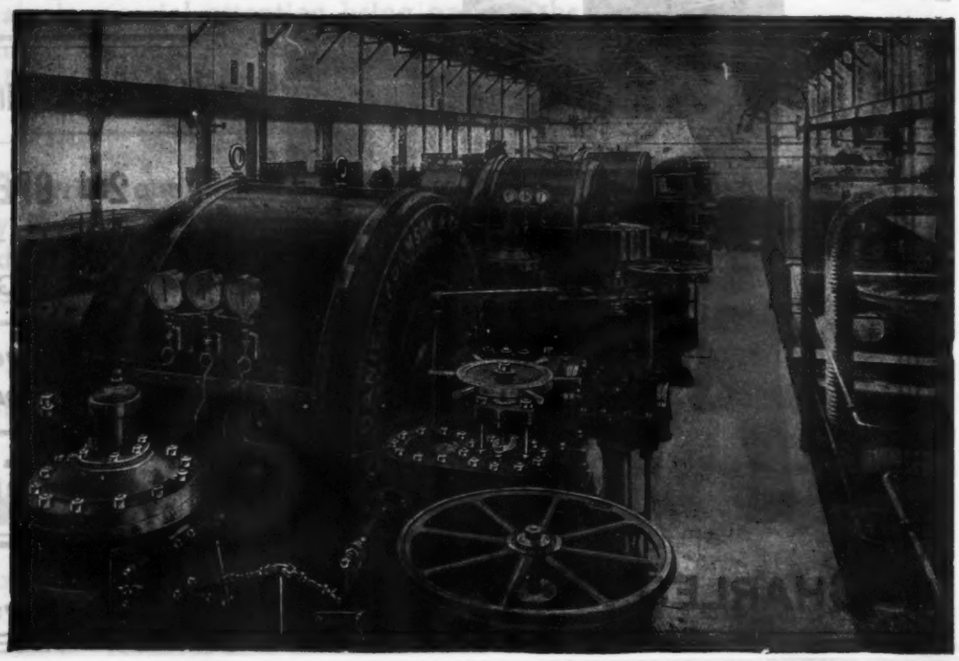
BOILERS.

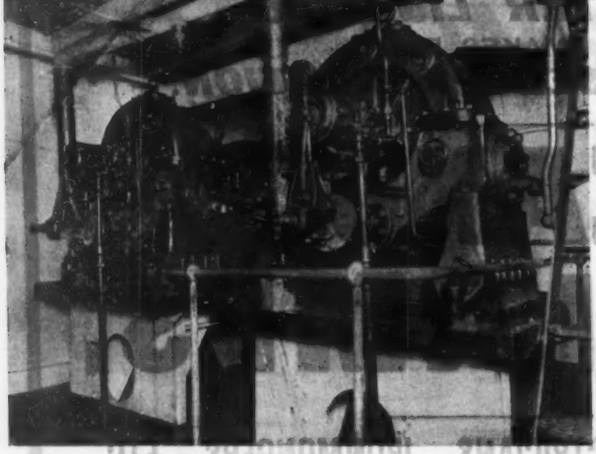
SUPERHEATERS.

STEEL VESSELS OF ALL CLASSES.

8459

DANIEL ADAMSON & CO., LTD., DUKINFIELD.





Two 25 Kw. Terry Turbo-Generator units installed on the steamer "Henry R. Mallory."

On Land or Sea

smooth operation with freedom from vibration is a virtue, particularly however, where units must be installed on very light foundations such as are shown in the illustration. This smooth operation is made possible by the short bearing span and the stocky shafts which are used bringing the critical speed well above the operating speed.

Freedom from vibration is but one of the features which have made

THE TERRY TURBINE

so successful in its operation. There are many others, such as the nozzle control feature giving practically full load economy at partial loads, extreme simplicity of design, complete accessibility to all wearing parts permitting inspection and repairs with minimum delay and without having to disturb either the exhaust or steam connections.

Bulletin 2515 gives complete information regarding these and the many other Terry features. It shows many applications and representative installations.

If you are now a turbine user or contemplate the possibility of a turbine installation, don't fail to investigate the turbine which for twenty years has shown it's superiority in many classes of service.

Write us or our English representatives, **Fraser & Chalmers' Engineering Works**, Erith, Kent, with branch offices in France, Belgium, China, India, Australia, Africa and South America.

T-622

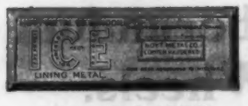
The Terry Steam Turbine Co., Hartford, Conn, U.S.A.

BEARING HOYT METALS.

ANTI-FRICTION (WHITE) METALS FOR ALL PURPOSES.

INGOTS FOR LINING.

DIE-CAST BEARINGS
IN NUMBER ELEVEN ALLOY.



INGOTS FOR LINING.

NUMBER ELEVEN

is the highest quality made (the materials costing more than those of any other anti-friction metal), and has been proved by leading engineers the most durable obtainable. It is guaranteed to give results better than any other. Number Eleven is used extensively for Diesel, Steamship, Turbine, Aero. and Automobile Engines.

Die-Cast Bearings in Number Eleven are the finest obtainable.

SPECIMENS BENT AND FLATTENED COLD TO SHOW TOUGHNESS.

DIE-CAST BEARINGS

true to .001" and ready for fitting, can be supplied in any grade or metal according to the purpose. Hoyt Die-Cast Bearings are employed for Machine Tools, Pumps, Air Compressors, Gear Boxes, Winches, Electric Motors, Automobiles, Aviation Engines, etc.

Write for prices and further particulars (enclosing blue prints or sketch). Expert advice free.

8668

Ask for interesting free leaflets on white-metalling and lubrication.

THE HOYT METAL CO., LTD.,

DEODAR ROAD, PUTNEY, LONDON, S.W.15.

TELEGRAMS: PROFANITY, 'PHONE, LONDON. TELEPHONES: PUTNEY 1323 AND 1324.

ROBEY ENGINES

The experience of over half a century in the manufacture of many thousands of drop valve engines is embodied in the Robey Uniflow Engine.

In Efficiency and Economy it stands alone.

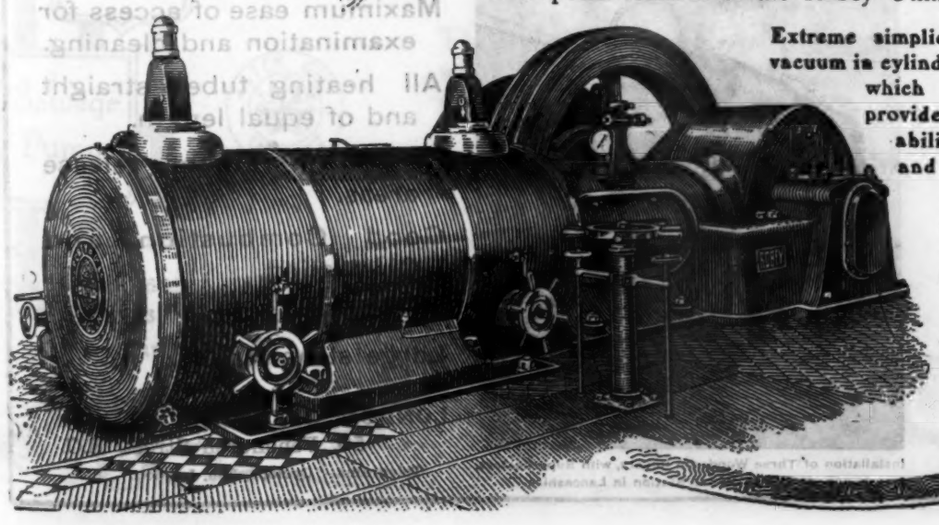
The special features of the Robey Uniflow Engine are:—

Extreme simplicity and low upkeep costs—High vacuum in cylinder—Accessibility of working parts which are all totally enclosed and provided with forced lubrication—Suitability for high steam pressure and all degrees of super-heat.

It is as efficient and economical as a high class triple expansion engine.

8645

Catalogue No. 246 on application.



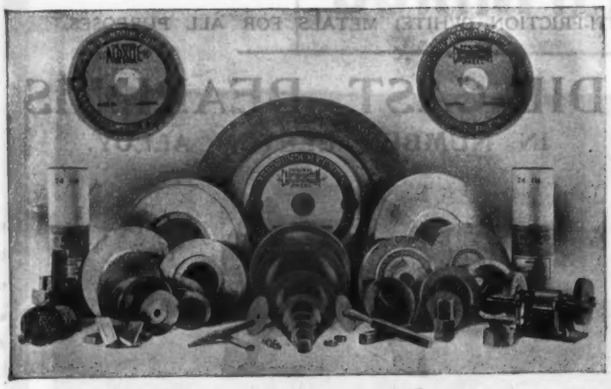
ROBEY & Co LTD
GLOBE WORKS LINCOLN

WE MAKE EVERYTHING IN THE ABRASIVE LINE.

Carborundum Wheels.

for Cast Iron, Brass, Bronze, Copper, etc.

Fast Cut—Long Life—Maximum Production.



Group of Carborundum Products.

Aloxite Wheels.

Ideal for Steel and Malleables.

Increased production at greatest grinding economy.

We also supply CARBORUNDUM FILES—indispensable in the Machine Shop; CARBORUNDUM CLOTH and PAPER, in Discs, Rolls and Sheets—the cloth and paper that CUTS, not rubs; CARBORUNDUM BRICKS—for dressing and scouring Castings, Chilled Iron and Steel Rolls, etc.; CARBORUNDUM and ALOXITE SHARPENING STONES; GRINDERS, hand, foot, and power-driven, etc. 8405

WHY NOT ASK OUR SERVICE DEPARTMENT TO SEND YOU FULL PARTICULARS OF ALL OUR MANUFACTURES—THEY WILL CERTAINLY INTEREST YOU.

THE CARBORUNDUM CO., LTD., TRAFFORD PARK WORKS, MANCHESTER.

CLARKE, CHAPMAN & CO., LTD.,

VICTORIA WORKS, GATESHEAD.

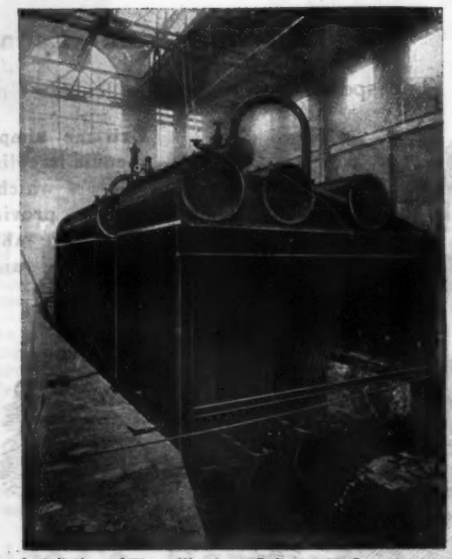
GENERAL & ELECTRICAL ENGINEERS & BOILERMAKERS.

WATERTUBE BOILERS.

"WOODESON'S" PATENTS

FOR ALL DUTIES.

Telegrams: CYCLOPS, GATESHEAD.
Telephone Nos.: 1070 & 1073 Central and No. 137, City
Trunk Calls: 2196, Central.
CODES:—
A. B. C. 4th & 5th Editions, A. 1., Engineering, 1st & 2nd Editions, Lieber's, Broomhalls, Morsing & Neil's, Watkins, Western Union, and Privates.



Installation of Three Woodeson Boilers, with Superheaters, supplied to large Power Station in Lancashire.

SPECIAL FEATURES:

Maximum ease of access for examination and cleaning.

All heating tubes straight and of equal length.

Maximum steam release areas.

Good Combustion and Circulation.

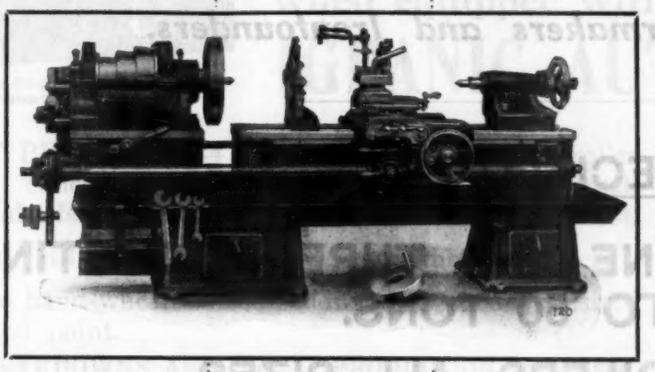
Ease in erection.

Large steam space. 8503

LONDON OFFICE:
50, Fenchurch Street, E.C.
Telegrams—"Cyclops, Fen, London."

POWER *plus* Convenience.

"WILLSON" LATHES efficiently handle all work within their capacity, which is a generous one, and at the same time survive the most exacting conditions of service.



THEY have unusual power and rigidity, taking deep roughing cuts with ease. "Willson" Lathes enable fullest advantage to be taken of the cutting capacities of modern high-speed steel.

A glance at the illustration will help you realise the operating convenience which makes "Willson" Lathes big producers.

Convenience of operation has been developed to a high degree in these machines; power and rigidity are built into them. They have won fullest apprcciation by reason of their 'power *plus* convenience' features.

Write for booklet giving full description of complete range of Willson Lathes.

Willson

(Smith, Barker & Willson, Ltd.)

Lathe Specialists.

WEST MOORSIDE, HALIFAX. J.J.M.

8005

'Phone: 46, Halifax.
'Grams: "Lathe, Halifax."

A B C Code, 5th and 6th Edition.
Western Union, 5 Letter Edition.
Marconi International.

ASTER
OIL ENGINES

ARC Welding Sets

Marine & Stationary Sets

Com-pressor Sets

Switch Boards

Salvage Pumps

Country House Lighting

Auxilliary Ships Lighting

Powers-5H.P. to 450 H.P.

Electric Generating Sets
for all purposes : 30,000 Engines in use

These figures denote the confidence which is placed in Aster production by engineers throughout the world.

For every power purpose there is an "Aster" Engine or Set.

THEY ARE BRITISH MADE THROUGHOUT.

8320

ASTER ENGINEERING CO. 1913 LTD.

Agents { GLASGOW—Drysdale & Co., Ltd., Yoker
BELFAST—4, Ocean Buildings, Donegall Square East.
CARDIFF—Western Mail Chambers, Stockton-on-Tees—Allison St.

Wembley, Middlesex.

A. F. CRAIG & CO., LTD.,

Caledonia Engine Works, PAISLEY.

Engineers, Boilermakers and Ironfounders.

SPECIALITIES.

HEAVY MARINE ENGINE AND TURBINE CASTINGS UP TO 50 TONS.

MARINE BOILERS—ALL SIZES.

OIL MILLING PLANT. SUGAR MACHINERY.

MINERAL OIL DISTILLING AND REFINING PLANT.

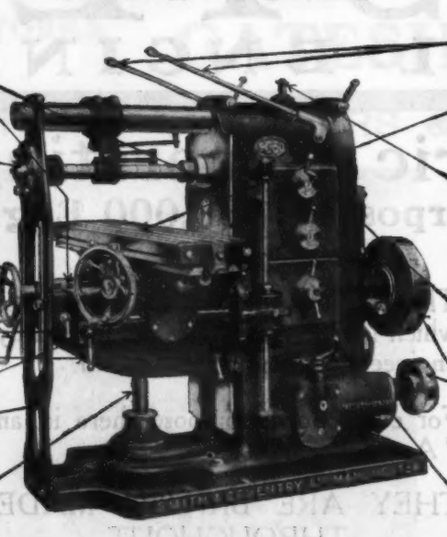
7886

SPECIAL FEATURES EMBODIED IN OUR SINGLE PULLEY PLAIN HORIZONTAL MILLING MACHINE OF HIGH POWER.

MADE IN 3 SIZES.

30" × 12" × 19"
36" × 12" × 19"
42" × 15" × 20"

The 42" Machine has Quick Power Return to all Slides.


SLIDE FACE WIDE. KNEE SLIDE LONG KNEE WIDE AND WITH CENTRAL NARROW GUIDE.
REMOVABLE BEARING, ALLOWS CUTTERS TO BE REMOVED WITHOUT DISTURBING BRACE.
ALL CONTROLS FROM OPERATORS POSITION.
TABLE CROSS ADJUSTMENT.
VERTICAL ADJUSTMENT
CROSS AND VERTICAL FEED CONTROL INTERLOCKED
REVERSE ALL FEEDS.
TABLE TRAVERSE HANDWHEEL.
BRACE TIES OVERARM, ARBOR BEARING KNEE AND BASE FIRMLY TOGETHER.
TELESCOPIC SCREW OF MAXIMUM EFFICIENCY MAKES VERTICAL MOVEMENT EASY
STOP, START & BRAKE, SPINDLE, FROM FRONT OR EITHER SIDE OF MACHINE
TABLE LARGE & WITH WIDE CHANNELS AND NON-CHOKING TELESCOPIC DRAIN.
DRIVING GEARS AND BEARINGS HAVE FLOODED LUBRICATION, OIL CIRCULATION VISIBLE HERE. LIBERAL INSPECTION COVERS BEHIND MACHINE.
16 SPEEDS BY SLIDING GEARS, NO IDLE GEARS RUNNING IN MESH.
BELT PULLS TAKEN ON BALL BEARING. NO HEATING OR EXCESSIVE WEAR. LARGE DIAMETER TOGGLE FRICTION CLUTCH FOR SPINDLE CONTROL.
SIMPLE ROTATION OF ONE CRANK GIVES ANY ONE OF 16 FEEDS ½ TO 20" PER MINUTE.
30" MACHINE.

Send for our Illustrated Catalogue Section of these Machines.

IMMEDIATE DELIVERY.

SMITH & COVENTRY Ltd.,

GRESLEY IRON WORKS,
MANCHESTER.

8707

Type 510-4 Magnetic Lock-out Contractor Switch Panel.

Modern Machine Tools yield the Best Output when equipped with "IGRANIC" AUTOMATIC CONTROL

CONTROL IGRANIC ELECTRIC DEVICES

TYPE No. 510-4 Speed Regulating Controller concentrates all control functions in one small hand-wheel fixed to and movable with the tool rest.

No skill is required to operate the controller.

The hand-wheel can be set instantly to any desired speed point.

BREAKDOWNS Abolished. PRODUCTION Increased.

Send for Leaflet No. 510.

Leaflet No. 510 tells more about this interesting and efficient method of control.

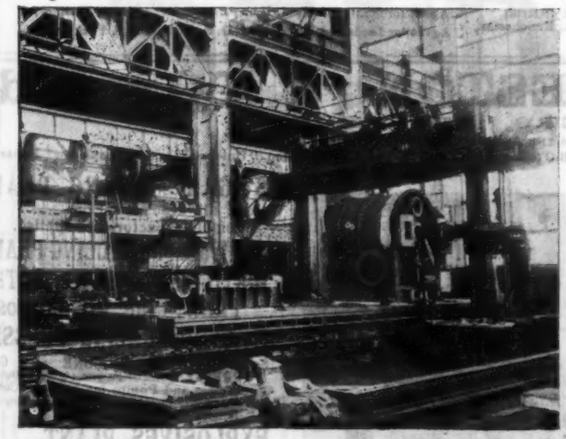
IGRANIC ELECTRIC Co LTD

147, Queen Victoria Street, LONDON.

Works: BEDFORD.

Branches: GLASGOW, MANCHESTER, BRADFORD. 8254

BETTS MACHINE TOOLS FOR PRECISION AND DISPATCH.



Dispatch means half the job done. Betts Machine Tools give the operator in addition to dispatch, precision and convenience of operation.

Betts Machines lighten onerous labour for the skilled craftsman.

Here is illustrated Betts Heavy Duty Planing Machine working on a cylinder of a large marine engine for use by the United States Shipping Board.

The work here illustrated is finished accurately and conveniently by means of the extension slide side heads.

A Betts Machine Tool for every need in heavy duty work. Let us have your problems. 9045

BETTS MACHINE COMPANY,

Blossom Road, Rochester,

NEW YORK, U.S.A.

Cable Address— "BETTS" ROCHESTER.

ESTABLISHED IN 1861.

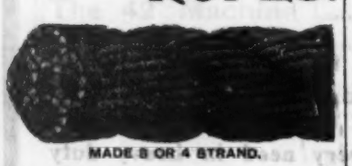
Paterson
WATER WORKS ENGINEERS
ENGINEERING COMPANY LTD
WINDSOR HOUSE KINGSWAY
8740

THERMOSTATS
— for —
Controlling Steam to CALORIFIERS OR HOT WATER TANKS. 9115
THE HORNE ENGINEERING CO.,
St. Peters Lane, Glasgow.

PLEASE NOTE
DANKS
NETHERTON

CHIMNEYS.
BOILER & ECONOMISER SETTINGS.
H & T. DANKS.
(NETHERTON) LTD.
BOILERMAKERS,
CHIMNEY BUILDERS, ETC.,
NETHERTON,
DUDLEY.

LAMBETH
COTTON DRIVING
ROPES.

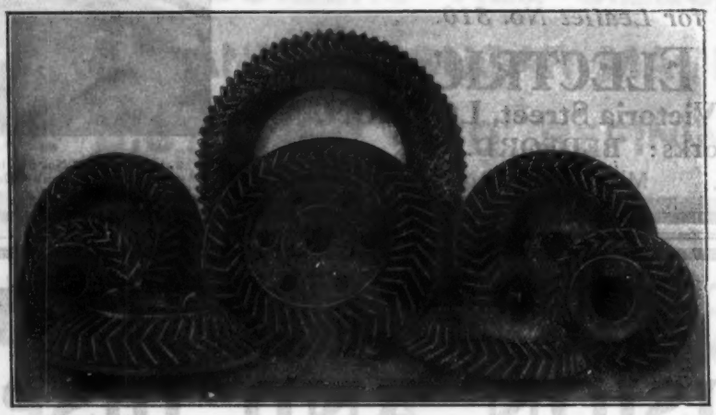


MADE 3 OR 4 STRAND.
Specially suitable for Drives in Engineering Works, Rolling Mills, Cement Works, Textile Factories, & Main Driving Generally.
Book on Rope Driving free on application
THOMAS HART, Ld.
LAMBETH WORKS,
BLACKBURN, 7286
Established 1789 ENGLAND.

DROP FORGINGS

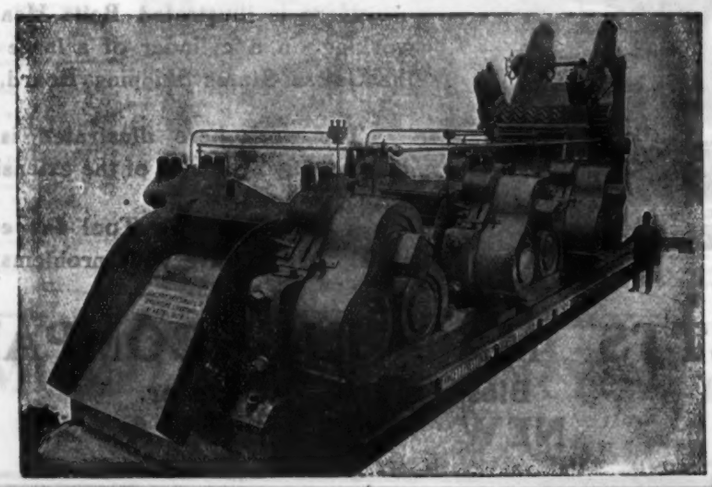
Heavy Front Axle Forging, Weighing 148 lbs.
A Product of THE
SCOTTISH STAMPING & ENGINEERING Co., LTD.,
TELEGRAMS: STAMPINGS, AYR. AYR,——SCOTLAND. 9031 TELEPHONE AYR 168.

STEEL CASTINGS.



MACHINE MOULDED CAST STEEL HELICAL BEVEL GEARING.
By Siemens-Martin and Crucible Processes of every description.
TO PASS ADMIRALTY, LLOYD'S, BOARD OF TRADE, OR BUREAU VERITAS TESTS.
Castings for Railways, Shipbuilding Yards, Engine Works, Rolling Mills, Iron and Bridge Works, Hydraulic and Electrical Machinery, Mining, River Dredging, Excavating Work.
8941
SPECIALITIES;
TOOTH WHEELS and PINIONS used in connection with Cranes, Winches, Capstans, &c.
Cast-Steel ANCHOR HEADS and DREDGER BUCKETS Fit up Complete.
W. SHAW & CO., Wellington Foundry, MIDDLESBROUGH
Telegrams—"WELLINGTON, MIDDLESBRO'." ON ADMIRALTY AND WAR OFFICE LISTS.
London Office—90, Cannon Street, E.C. Representative—A. H. SHARPE.
Office for Manchester and Birmingham Districts, 12, Exchange St., Manchester. Representative—THOS. F. W. DIXON.
Agent for Scotland—H. M. HARPER, 93, Hope Street, Glasgow.
Agent for Leeds and District—G. G. S. GRUNDY, 6, Park Square.

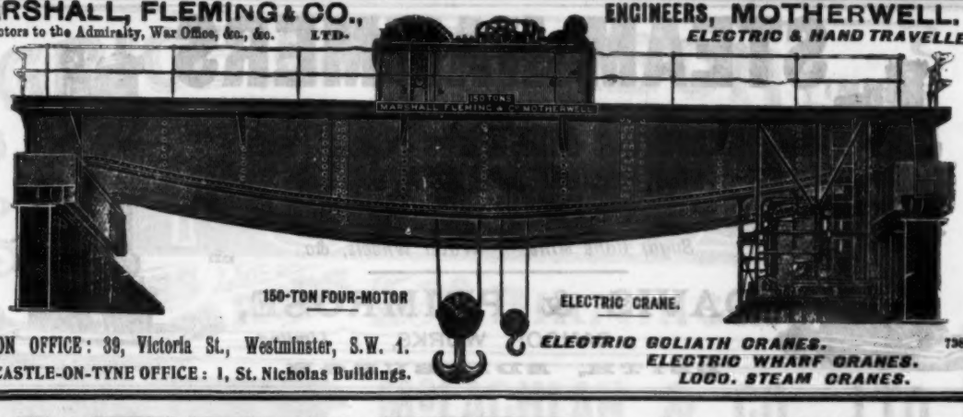
FAWCETT, PRESTON & CO., Ltd.,
ENGINEERS, LIVERPOOL.
CONTRACTORS TO THE ADMIRALTY AND WAR OFFICE.
Telegrams: FAWCETT, LIVERPOOL. Codes used: A 1, A B C (4th and 5th Editions) and Western Union ("Universal" and "Five Letter" Editions).



AN ELEVEN-ROLLER CANE-GRINDING PLANT.
SUGAR MAKING PLANT of all kinds.
Complete Factories Supplied.
Sea Water DISTILLING PLANT.
DISTILLING and EVAPORATING PLANT for all purposes.
Hydraulic BALING PRESSES.
Sole Makers of CYCLONE and GRID PRESSES, and of Fawcett's High Density Presses and Pumps for packing Cotton, Jute, Wool, Hides, &c., of any required density and weight of bale.
EXPLOSIVES PLANT.
NITRATE-MAKING PLANT.
MARINE and STATIONARY ENGINES and BOILERS.
PUMPING MACHINERY for Towns Water Supply.
COPPERSMITHS and BRASS FOUNDERS.
8968
LONDON Office: 69, Victoria St., S.W.1.

MARSHALL, FLEMING & CO., LTD.
Contractors to the Admiralty, War Office, &c., &c.

ENGINEERS, MOTHERWELL.
ELECTRIC & HAND TRAVELLERS.



150-TON FOUR-MOTOR ELECTRIC CRANE.

LONDON OFFICE: 39, Victoria St., Westminster, S.W. 1.
NEWCASTLE-ON-TYNE OFFICE: 1, St. Nicholas Buildings.

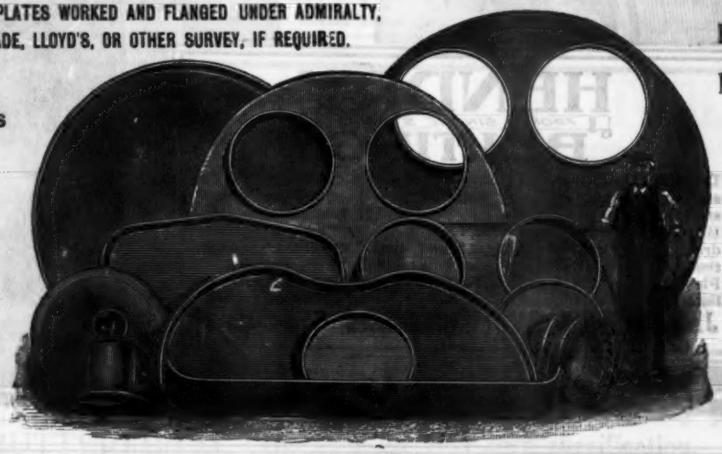
ELECTRIC GOLIATH CRANES.
ELECTRIC WHARF CRANES.
LOCO. STEAM CRANES.
7304

ABBOTT & CO.
(NEWARK, LIMITED),
NEWARK-ON-TRENT, ENGLAND.

Telegraphic Address: "ABBOTT, NEWARK." Telephone: No. 34. ABC Code, 4th & 5th Editions.

WELDED & FLANGED WORK
OF EVERY DESCRIPTION.
CUSTOMERS' OWN PLATES WORKED AND FLANGED UNDER ADMIRALTY, BOARD OF TRADE, LLOYD'S, OR OTHER SURVEY, IF REQUIRED.

CONTRACTORS TO THE ADMIRALTY, WAR OFFICE, INDIA OFFICE, BOARD OF CUSTOMS, CROWN AGENTS, &c. &c.



FROM PHOTO.

DEGREASING PLANTS.
MOTOR VAN BOILERS.
HYDRO CASINGS.
REPAIR FIRE BOXES.
EVAPORATOR SHELLS.
AIR RECEIVERS.
VULCANISING PANS, &c., &c.
7415

BELDAMS
PILOT
JOINTING
FOR
STEAM, WATER, OILS & ACIDS

Solo Patentees and Manufacturers
The
BELDAM
PACKING & RUBBER CO. LD.
29, Gracechurch Street,
LONDON, E.C. 3.
ESTABLISHED 1876.
Works: BRENTFORD, MIDDLESEX
'Grams: "Veepilot, Lod, London." 'Phones: Avenue 3204 & 1982. Code: A B C, 5th & 6th Editions.
STOCKS AT
BRISTOL, CARDIFF, GLASGOW, HULL, LIVERPOOL, LEITH, MIDDLESBROUGH, SOUTHAMPTON, SUNDERLAND,
and principal Ports throughout the World.

ONE INCH SQUARES FOR QUICK CUTTING OF JOINTS
JOINTING PILOT JOINTING PILOT JOINTING PILOT
SQUARES FOR QUICK CUTTING OF JOINTS MARKED IN ONE INCH SQUARES.
8907

Magnet CRANES for Handling Pigs or Ore
John Grieve & Co.
Motherwell. . .
7218

MAGNETIC-ADHESION
Electric Drill
LABOUR SAVING TOOL.

A Good Investment with Big Profits for You.

No Erection Required.
Place in position and switch on.

WHITE, JACOBY CO., Ltd.,
HEAD OFFICE & WORKS:
Bayham Place, Camden Town,
LONDON, N.W. 1.
Telephone No.: North 2066. 9638

THE
LEEDS ENGINEERING
AND
HYDRAULIC CO., Ltd.
RODLEY near LEEDS.

PUMPING &
HYDRAULIC
MACHINERY
Etc.

8708

Telegrams: "PUMPS, RODLEY." | REGISTERED TRADE MARK | Code: ABC, 5th Edition.
Telephone: 160 STANNINGLEY. | MARCONI INTERNATIONAL.

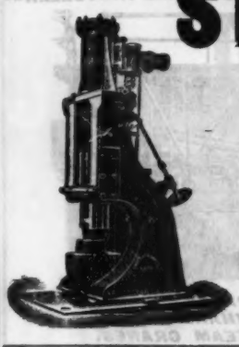
POWER
TRANSMISSION
APPLIANCES.

THE PULLEY.

Brackets.	Eccentrics, adjustable.
Bearings, cast iron.	Hangers.
„ brass lined.	Lubricators.
„ ball socket.	Pulleys, cast iron.
„ self-oiling.	„ wrot. iron.
„ solid grease.	Shafting.
Collars.	Slings.
Couplings.	Stands, &c., &c.
Countershafts.	

JOHN JARDINE,
Limited,
DEERING ST., NOTTINGHAM.
Telegrams: "JARDINE, NOTTINGHAM."
Telephone: Nos. 3295 and 3296.

STEAM HAMMERS



FOR SMITHS' SHOPS AND FORGES.
Shipbuilders & Boiler Makers' Machine Tools.
PATENT BEVELLING MACHINES FOR SHIPS' FRAMES.
FORGE CRANES, Hand and Steam.
Sugar Cane Mills. Water Wheels, &c.

8323

DAVIS & PRIMROSE,
BANGOR WORKS, *Limited.*
LEITH, EDINBURGH.

HENDRY
FROM A SINGLE STRAND
BELTING

THESE ILLUSTRATIONS are drawn to scale. They show the striking advance made by Hendrys' new patent Flexible construction over the old style. . . . HENDRYS' Laminated Leather BELTING is now guaranteed to give efficient and satisfactory driving over Pulleys ONE-HALF and even TWO-THIRDS smaller than is practicable with any other type of flat belting. The extreme Flexibility of HENDRY BELTING ensures perfect distribution of load over the driver and driven pulleys. Particulars on request.

JAMES HENDRY, LTD. 269 Main Street BRIDGETON GLASGOW

Copyright Registered

8245

Heavy Steel Gear Case.

SANKEY
Durable
Steel Stampings
and Pressings

A powerful and very extensive plant enable Sankeys to speedily turn out combinations of stamped or hydraulically pressed, riveted and welded work of all descriptions; with or without machining. Thickness: anything from 20 gauge sheets to ¾ in. plates, in steel or other material.

Just let us know your requirements and we will quote you by return.

JOSEPH SANKEY
and SONS, Ltd.,
Wellington, Shropshire.
Telephone: 66 Wellington.
Telegrams: "Sankey, Wellington, Salop."

8768

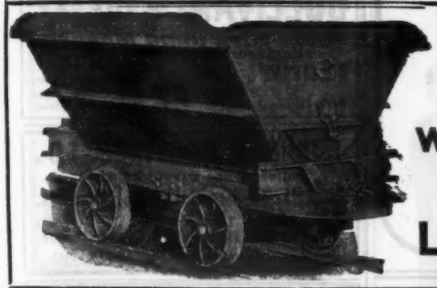
GRICE, GRICE & SON LIMITED

CONTRACTORS TO HIS MAJESTY'S GOVERNMENT

BRASS & COPPER, LOCO & CONDENSER

TUBES

PLATES & RODS &c &c BIRMINGHAM.



McLACHLAN & CO., LTD.,

DARLINGTON.

MANUFACTURERS OF

WAGONS OF ANY CAPACITY FOR ALL GAUGES.

Speciality:

LIGHT RAILWAY PLANT.

London Office - - - - 110, CANNON STREET, E.C. 4. 8236

H. Coltman & Sons

(Branch of Herbert Morris Ltd.)

Loughborough.

Tel. Address: "COLTMANS, LOUGHBOROUGH."

BOILER MAKERS.

8814

TANKS, CISTERNS & CYLINDERS, from 20 to 3000 gals. capacity, and up to ¼ inch thick.

Your enquiries are respectfully solicited for our lists.

We are able to supply anything in Galvanised Iron, for any purpose to your own specification.

W. P. BUTTERFIELD, Ltd.,

Shipley, Yorks.,
England.

'Phones: 35 & 535, Shipley.

'Grams: Tanks, Shipley.

9044

M.H.

JOHN Thompson WOLVERHAMPTON

Superheaters

(PATENT No. 1817 of 1917.)

Right and Left Hand Nest Thread. By tightening or releasing this, the tube is fixed or removed in less than a minute

REDUCE YOUR COAL BILL.

8406

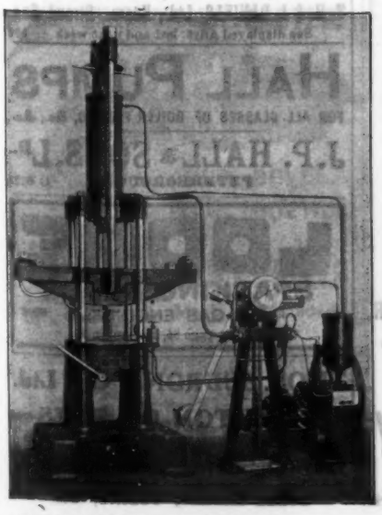
ALFRED J. AMSLER & CO.,

OF SCHAFFHOUSE, SWITZERLAND

Make all sizes of 'Universal' and special purpose

TESTING MACHINES

for Tension, Compression, Bending and Shearing tests of metals and other constructional materials.



Fifty-ton Universal Testing Machine with Pendulum Dynamometer and Motor-driven Oil Pump.

New designs of Torsion Testing Machines and Dynamometers. Bending, Compression and Tension Testing Machines, for leaf and coiled Springs. Pendulum Impact and Repeated Impact Machines, also new designs of Hardness and Abrasion Testing Machines.

Write for full particulars and English Catalogue to—

T. J. PRIMROSE, 8705

162, NORWICH ROAD, IPSWICH.

ELEVATORS, CONVEYORS, FANS, ETC.
W. J. JENKINS & Co. LD.
ENGINEERS
RETFORD NOTTS.

CONTRACTORS TO H.M. GOVERNMENT.
The Metallic Manufacturing Co., Ld.
ARDROSSAN.
METALLIC DISC VALVES, 8673
CORRUGATED METALLIC JOINTS,
and other ENGINEERING SPECIALITIES.
Illustrated Catalogue on Application.
See Illustrated advt. in issue of December 24.

BERTRAMS LIMITED
EDINBURGH
PAPER MILL Machinery
60 YEARS EXPERIENCE

NEW WOODEN HUTS.

Dwellings, Bungalows, Offices, Workshops, Motor Car Houses, Pavilions, Stables, Stores, Canteens, Greenhouses, Frames, Heating Apparatus, Rustic Work, Barrows, Stoves, Asbestos, Sheets, Poultry Appliances of every description, Glass (Horticultural, window and picture).
Illustrated List Post Free.
T. BATH & CO. LTD. 18 SAVOY ST. LONDON W.C. 2

PURE WATER
for all purposes,
Particulars from 4361
The BUHRING'S Patent WATER PURIFYING Co.,
60, Wilson Street, E.C.

THE "STONE" SYSTEM
OF
HYDRAULICALLY OPERATED
WATERTIGHT DOORS.
As fitted to latest Mail and Passenger Steamers.
J. STONE & CO., LTD.,
Deptford, London, S.E. 8660

BULL'S METAL & MELLOID CO.
HEAD OFFICE AND WORKS: LIMITED.
YOKER, near GLASGOW.
TELEGRAMS: "MELLOID, YOKER."
BULL'S METAL.—Propellers, Bars, Sheets, Pump Rods, Valve Spindles, Condenser Stays & Plates, &c.
MELLOID. (Reg. Trade Mark and Patented.)—Condenser Tubes, Plates and Stays, Boiler Tubes, Stays and Plates, Fire-box Plates, Bars, Sheets, Valves, &c.
WHITE METALS.—Babbitts, Plastic, &c. 8660

"Asquith" Drills Pay.
Ask the User! 4368
Special deliveries on many sizes.
Radials 3½ ft. to 12 ft.: Verticals up to 5 ft. Various size Horizontals.
Wm. ASQUITH, Ltd., Park Works, Halifax. || *See Displayed Advt. Dec. 24.*

THE STEEL PIPE CO.
LIMITED, 8612
KIRKCALDY, N.B.
See our large Advertisement on alternate weeks.

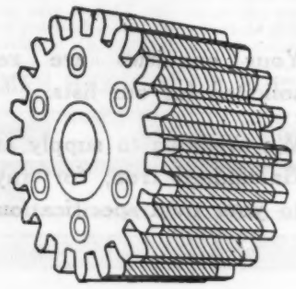
ENTWISLE & GASS, LD.,
Engineers, BOLTON.
For CENTRIFUGAL PUMPS, AIR COMPRESSORS, CLUTCHES, GEARING, CASTINGS up to 10 TONS, BLEACHING, DYEING & PRINTING MACHINERY. 1170

JOHN SPENCER, LD. 8586
WEDNESBURY.
IRON & STEEL
TUBES
POLES, STEAM MAINS, TUBULAR PILES, &c.

ROBERT STEPHENSON & CO., LTD.
LOCOMOTIVE BUILDERS, DARLINGTON.
London Office:—Sanctuary House, Westminster.
LOCOMOTIVES for all gauges and services.
Telegrams—Rocket, Darlington: Alkicope, London.
Nat. Tel.—709 Darlington; 95 Victoria.
Codes—A B C 5th Edition, Engineering Standards, Engineering Telegraph.
See our Illustrated Advt. last and next week.

"SUNDERLAND" GEAR PLANERS

8098
J. PARKINSON & SON,
SHIPLEY, ENGLAND.

RESILIENT STEEL GEARS.
(SEYMOUR'S PATENT.)
STRENGTH — SILENT —
DURABILITY — ADAPTABILITY —
EFFIOIENCY — AUTOMATIC LUBRICATION. —

Sole Makers:— 8837
THOS. SUMMERSON & SONS, Ltd., DARLINGTON.

PROCTOR'S PATENT SHOVEL STOKER
AND
MOVING FIRE-BARS
Give ECONOMY in FUEL,
Increased Steam Production,
SMOKE ABATEMENT.

PROCTOR'S COAL ELEVATOR,
fitted with Patent RAM FEED BOOT,
Ensures cheap handling of the coal.
POSITIVE FEED OF COAL TO BUCKETS. NO JAMMING OF ELEVATOR.
Wear and Tear reduced to a minimum. Od 2945
Write for Illustrations and Particulars.

JAS. PROCTOR LD., Hammerton St. Iron Works. BURNLEY.
SOLE AGENTS FOR FRANCE AND BELGIUM:
The Societe des Perfectionnements a la Vaporisation, 68, Rue de Rome, Paris.

THE CONSOLIDATED BRAKE & ENGINEERING COMPANY, LIMITED, 8280
15, DEAN'S YARD, WESTMINSTER, S.W.
MANUFACTURERS OF THE
STANDARD AUTOMATIC VACUUM BRAKE
AND
Rapid Acting Service & Emergency Accelerators
See Illustrated Advertisement Dec. 24.
Telg.: "Vacuo, Vic., London." Tele. No.: Victoria 2967.

PATENT RIGHTS, PATTERNS, STOCK AND PARTS OF THE
"Simplex" Bacon Slicing Machine
FOR SALE.
Good opportunity for starting small Engineering business.
APPLY:
BARKER SPINK & LEASE, Park Wks., Rosse St.
SHIPLEY. 6131

BULLIVANT & CO., LD.
Steel Wire Rope Makers,
Engineers and Contractors,
BULLIVANT'S AERIAL ROPEWAYS, Ltd.,
72, MARK LANE, LONDON, E.C. 8185
Works: MILLWALL, E. Tele: 2168 Avenue (3 lines).

MICHELL BEARINGS, LD.,
ENGINEERS and MANUFACTURERS OF
Michell Thrust & Journal Bearings.
London Office: 8961
3, Central Buildings, Westminster.
See large Advertisement, page 82, Dec. 24th.

AILSA SHIPBUILDING CO.,
LIMITED.
Shipbuilders, Engineers, and Repairers, 9029
TROON and AYR.
See Displayed Advertisement last week and next week.

MOTORS & DYNAMOS

SAVORY & COULSON 17 & 19 BROAD ST. GLASGOW

J. TOMEY & SONS LTD.

EUREKA GAUGE GLASS
ESTABLISHED 1853
ASTON
BIRMINGHAM 1437

"BRITNIC"
— 4,000,000 HP in Service. —
WATER TUBE BOILERS and MECHANICAL STOKERS.
(200,000 HP in Service.) 8817
The British Niclausse Boiler Co., Ld.,
The Clock House, Arundel St., Strand, W.C. 2.

DANIELS GAS PLANTS
DANIELS GAS ENGINES
DANIELS HIGH-SPEED PUMPS
Complete Pumping Installations.
T. H. & J. DANIELS, Ltd., Engrs., Stroud, Eng.
See displayed Advt. last and next week 806

HALL PUMPS
FOR ALL CLASSES OF BOILER FEEDING, &c., &c.
J. P. HALL & SONS. LD.
PETERBOROUGH. 8023

LODGE
SPARKING PLUGS
FOR GAS ENGINES. 8296
See Advt. page 85, December 24.

THOS. SUDRON & Co., Ltd.
STOCKTON-ON-TEES. 8560
MAKERS OF MARINE AND VERTICAL TYPE BOILERS. SHIPS MASTS. TANKS. MOORING BUOYS STEEL LADLES, TUBING, Etc.

THE
CLEVELAND BRIDGE AND ENGINEERING CO., LTD. 8821
Specialists in the Design, Manufacture, and Erection of Bridges, Girders, Roofs, Warehouses, and all classes of Iron and Steel Constructional Work.
HEAD OFFICE AND WORKS—
DARLINGTON.

CAST IRON & G.M. COCKS
FOR GAS STEAM AND WATER.

8754
BRITISH STEAM SPECIALTIES LD.
BEDFORD STREET, LEICESTER.

ELECTRIC MOTORS
LARGE SELECTION ALWAYS IN STOCK FOR IMMEDIATE DELIVERY.
MALCOLM & ALLAN, Ltd.,
ELECTRIC LIGHTING AND POWER CONTRACTORS. 8336
499, Eglington Street, GLASGOW.
6 schon Buildings, 12, Henrietta Street, Strand. LONDON, W.C. 2.
17, North Saint Andrew St., EDINBURGH.

PURE OAK-TANNED LEATHER BELTING
The BEST is the CHEAPEST.

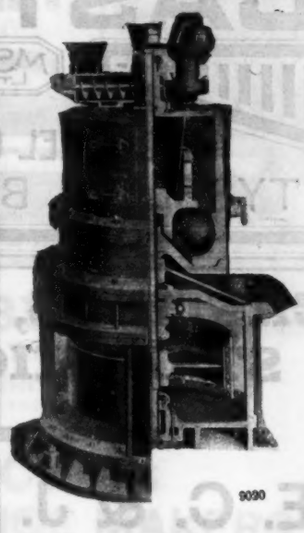
HOYT'S 'FLINTSTONE'
For all Drives. Gives Best Results.
Hoyt's 'Turtle' Brand. Guaranteed Waterproof. A.1. for wet or steamy places.
Hoyt's Cement stands the test.
Sole Agents for United Kingdom.
Est. 1835. Trade Mark.
BALDERSTON & CO. LTD.
201, St. Vincent Street, GLASGOW. 7501

On Admiralty List.
BODLEY BROS & Co.
Engineers, Millwrights, Boiler Makers, and Iron and Brass Founders.
OLD QUAY FOUNDRY, EXETER.

SPUR, BEVEL, MITRE, MORTICE, AND
WORM WHEELS,
Machine Moulded
ALSO
TEETH CUT TO SHAPE
By Special Machinery.
Telegraphic Address— 8418
BODLEY, EXETER.
ESTABLISHED 1790.

Pulverized Coal Equipment

AMONG some of the plants using our Pulverized Coal Equipment for heating Industrial Furnaces and Steam Boilers are the following.


9020

AMERICAN IRON & STEEL CO.,
Open Hearth, Puddling and Heating Furnace.
AMERICAN LOCOMOTIVE WORKS.
Steam Boilers.
AMERICAN SMELT. & REFINING CO.
Reverberatory Furnaces.
AMERICAN STEEL & WIRE CO.,
Open Hearth Furnaces.
AMERICAN STEEL & WIRE CO.,
Heating Furnaces.
ATCHISON, TOPEKA & SANTA FE R. R.
Locomotives.
ATLANTIC STEEL COMPANY.
Open Hearth Furnaces.
ASH GROVE LIME & PORTLAND CEMENT CO.,
Steam Boilers.
BETHLEHEM STEEL CO.,
Open Hearth Furnaces.
CHOCTAW PORTLAND CEMENT CO.,
Steam Boilers.
INLAND STEEL CO., Heating Furnaces.
LACKAWANNA STEEL CO., Calciping and also Flue Dust Nodulizing Kilns.
M.K. & T. RAILROAD, Steam Boilers.
MILWAUKEE ELECTRIC LIGHT & POWER CO.,
Steam Boilers.
NICHOLS COPPER COMPANY, Smelter.
PACIFIC COAST COAL CO., Steam Boilers.
PITTSBURG MALLEABLE IRON CO.,
Malleable Furnaces.
SIZER FORGE COMPANY,
Heating and Forging Furnaces and Steam Boilers.
SCRANTON BOLT & NUT CO.,
Heating and Puddling Furnaces.
SPANISH-AMERICAN IRON CO.,
Ore Roasting and Nodulizing Kilns.
STONE & WEBSTER CO., Steam Boilers.
UNION CARBIDE COMPANY, Lime Kilns.
UNITED VERDE EXT. MINING CO.,
Reverberatory Furnaces and Steam Boilers.

Practically all the Cement Plants in the United States and Canada have installations of Fuller Mills.

Some of the above plants are using Pulverized Coal containing from 10% to 17% of ash for heating their metallurgical furnaces.

Fuller Mills are to-day pulverizing over 25,000 tons of coal per day for heating various types of Furnaces.

The satisfactory performance of our pulverized Coal Equipment warrants your investigation. We manufacture Coal Crushers, Dryers, Fuller-Lehigh Pulverizer Mills, and Pulverized Coal Feeders. All this equipment is described in our Catalogue No. 71, which we will be pleased to send you.

FULLER-LEHIGH COMPANY,
Main Office and Works - - FULLERTON, Pa., U.S.A.
BRANCH OFFICES:—NEW YORK, N.Y., U.S.A., 50, Church Street; CHICAGO, ILL., U.S.A. McCormick Buildings. PARSONS, KANSAS, U.S.A. First National Bank Building.
Special Representatives in the Iron, Steel and Copper Industries for the British Isles: WELLMAN, SEAVER & HEAD, Ltd., LONDON.
LONDON OFFICE:—25, Victoria Street, Westminster, S.W. 1.
Telephone: 4280 Victoria. European Manager: L. C. HARVEY. Telegrams: Fuelecon, 'Phone, London.

WESTOOL
ELECTRIC PORTABLE TOOLS
DELIVERIES FROM STOOK.
No. 1 size—Mark I. DRILL for ¼ in. hole. 110 volt and 220 volt D.C. (Leaflet No. 95.)
No. 3 size—Mark I. DRILL for 1¼ in. hole. 110 volt and 220 volt D.C. (Leaflet No 90.)
ELECTRIC PORTABLE BLOWER. 110 volt or 220 volt A.C. or D.C. (Leaflet No. 93.)
Write for Prices and Leaflets. 8589
THE WESTMINSTER TOOL & ELECTRIC CO.,
WESTOOL WORKS,
Putney Bridge Road,
PUTNEY, LONDON, S.W. 15.
Telephone—Put. 1770.

KENYON'S PATENT OIL FILTER AND WATER SEPARATOR.
Over 900 ordered by H.M. Government.
ENGINEERS' STORES TOOLS.
ALEXANDER KENYON & CO., LTD.,
Victoria Bridge, MANCHESTER. 8921

STANDARD FANS

FOR VENTILATING, FUME EXHAUSTING, DUST COLLECTING, ETC., ETC.
Standard & Oswald Stott (Engineers), LTD.,
LEICESTER. 8503

EMPIRE ROLLER BEARINGS
EST. 1896.
BRITISH MADE.
ROLLER BEARINGS. SOLID ROLLERS.
IMPROVE EFFICIENCY.
TAKE HEAVY LOADS.
INCREASE PRODUCTION. 8949
SAVE POWER.
HAVE A GOOD RECORD.
THE EMPIRE ROLLER BEARINGS CO., LTD.
LONDON: 15, VICTORIA ST. IPSWICH: WATERSIDE WORKS.
SEND FOR CATALOGUE.

STOCK BOILERS.

MOST MODERN DISH-END TYPE.
WITH CORRUGATED SECTIONS.

One	30' 0" × 9' 3"	× 150 lbs. W.P.
Two	30' 0" × 8' 3"	× 160 lbs. W.P.
Two	28' 0" × 7' 6"	× 160 lbs. W.P.
Two	28' 0" × 7' 6"	× 150 lbs. W.P.
Six	28' 0" × 7' 6"	× 120 lbs. W.P.
Four	28' 0" × 7' 3"	× 160 lbs. W.P.
Eight	24' 0" × 7' 3"	× 120 lbs. W.P.
One	28' 0" × 7' 3"	× 160 lbs. W.P.
Two	28' 0" × 7' 3"	× 120 lbs. W.P.
One	24' 0" × 6' 6"	× 120 lbs. W.P.
One	28' 0" × 7' 3"	× 160 lbs. W.P.

Repairs to all types of Boilers by First-class Men.
John Thompson (Wolverhampton), Ld,
WOLVERHAMPTON, Eng. 8131

THE SCLEROSCOPE.

For Hardness Testing

in shop and laboratory use the

Standard Scleroscope

Universally adopted; direct reading; inexpensive, and the only instrument that agrees with others of its kind in all parts of the World, thus solving problems of ordering materials to specification.

BOOKLET FREE. 7746

Heated objects as seen through Pyroscope.

Heat Indication

by optical means is fast becoming the correct thing. The PYROSCOPE has solved the problem. Perfect constancy, inexpensive, no electricity used. Built to stand rough usage and upon common-sense lines. Used by the Governments and best Firms.

THE PYROSCOPE.

SHORE INSTRUMENT & MFG. CO.,

Van Wyck Avenue and Carll Street, Jamaica, N.Y.

Agents for England:—COATS MACHINE TOOL CO., LTD., 14, Palmer St., Westminster, London, S.W. Glasgow & Newcastle-on-Tyne.

ELECTRIC STEEL CASTINGS

MSC LTD

MILD STEEL CASTINGS LTD.

TYSELEY, BIRMINGHAM.

Send for Facts & Figures relating to actual tests carried out in a

DAVIS

Revergen

FURNACE

showing an Economy of 70% in the production of Forgings

The DAVIS FURNACE Company,

(Proprietors: The Davis Gas Stove Co.).

Diamond Foundry, Luton, Beds.

CASTINGS, COLUMNS, STANCHIONS, &c.

WANTED BY

E. C. & J. KEAY, LTD.

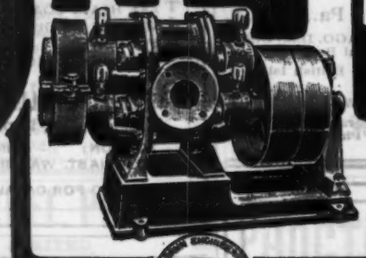
DARLASTON.

HEAD OFFICE: CORPORATION STREET, BIRMINGHAM.

LONDON OFFICE: 25, VICTORIA STREET WESTMINSTER, S.W. 1.

8139

THE DRUM PUMP



WRITE FOR DESCRIPTIVE CATALOGUE No 90

NO VALVES TO GET OUT OF ORDER. POSITIVE ACTION

TELEGRAMS: "DRUM BRADFORD"

THE DRUM ENGINEERING CO. Ltd.

28, Humboldt St., BRADFORD.

EVERITT & CO. LIMITED

40, CHAPEL STREET,

Telegrams: "PERSISTENT."

Telephone: 2995 CENTRAL (3 lines). LIVERPOOL.

SPIEGELEISEN

FERRO-CHROME. 0/5%, 2%, 4/6%, 6/8%, 8/10% Carbon.

FERRO-SILICON. 9/13%, 25%, 45/50%, 75%, 80/85%, 90%.

ALUMINIUM (Notched Bars, Half-round Sticks, Granules, and Powder.)

FERRO-MOLYBDENUM. MAGNESIUM METAL.

SILICON-MANGANESE.

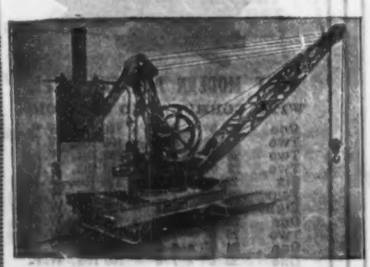
MANGANESE METAL, CHROMIUM METAL (Carbon free).

MINERALS:

MANGANESE, CHROME, WOLFRAM, SCHEELITE, MOLYBDENITE, FLUORSPAR, MAGNESITE, KIESELGUHR, ASBESTOS, GRAPHITE, ANNEALING IRON ORE, PIG IRON, &c., &c.

8171

ANDERSON CRANES.



Possess outstanding features which ensure low running costs and higher efficiency.

All gear above the swing plate is machine cut, the engine work is of the highest quality, there is a big margin in cylinder capacity, and the drums and pulleys are large in diameter.

LOCO Cranes supplied up to and including 15 tons capacity—electric, steam or hand.

Complete Catalogue sent on request.

THE ANDERSON-GRICE CO., Ltd.,

(FORMERLY GEO. ANDERSON & CO., LTD.),

Taymouth Engineering Works ——— CARNOUSTIE, SCOTLAND.

LONDON OFFICE: Queen Anne's Chambers, Tothill Street, Westminster, S.W.1. 826

PORTABLE ELECTRIC DRILLS.

L 198

DRILLS

Capacity in Steel ⅝ in.

UNIVERSAL DRILLS:

Capacity in Steel ½ in.

Automatic Speed Regulation.

Light—Strong—Efficient.

Noiseless Running.

Great Overload Capacity.

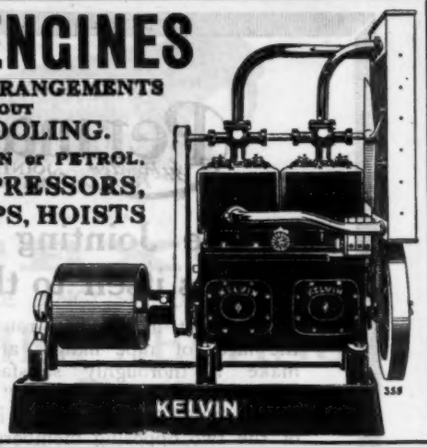
HIRST, IBBETSON & TAYLOR,

57-58, Chancery Lane,

LONDON, W.C. 2.

KELVIN ENGINES

70 STANDARD ARRANGEMENTS
WITH OR WITHOUT
RADIATOR COOLING.
3 to 60 HP. on PARAFFIN or PETROL.
For AIR COMPRESSORS, DYNAMOS, PUMPS, HOISTS
and all jobs requiring a power unit of absolute dependability. 8897



Complete Manufacturers—
THE BERGIUS LAUNCH AND ENGINE CO., LTD.,
254, DOBBIE'S LOAN,
GLASGOW.

"THE LANCASTER"
SUPER-LIMIT PISTON RINGS.

No loose parts.

No tongue pieces required.

Specially designed to meet the increased pressures and speeds now obtained.
Illustrated leaflet on application.

LANCASTER & TONGE, LTD.,
Sole Makers of "The Lancaster" Steam Traps, Pistons, Limit Piston Rings, Steam Dryers, Machine Moulded Wheels, &c. 8926
PENDLETON, MANCHESTER.

FORBES BROTHERS
(Universal Tool Co.),
Doe Street, Birmingham.
(Telephone—CENTRAL 857.

HIGH CLASS TOOL & GAUGE MAKERS.

SPECIALITIES.
Small Machine Tools, Graduated Swivel Machine Vices in various sizes, Plain Indexing and Universal Dividing Heads.
8839

Phone—2519 L'ster. # EXCAVATORS. Telegrams—Excavator.

STEAM and ELECTRIC CRANE EXCAVATOR.
" " CHAIN BUCKET EXCAVATOR.
" " TRANSPORTERS FOR MINES.
STEAM, ELECTRIC and PETROL TRENCH EXCAVATORS.
ELECTRIC TUNNELLING EXCAVATOR (Standard Size), from 5 ft. dia. to 8 ft. 2 in. Tunnels.

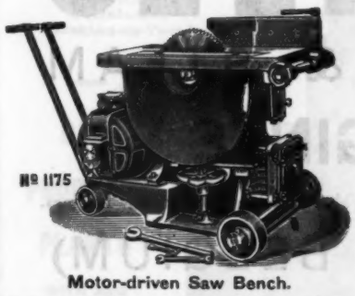
Had Repeat Order for the largest Excavator in the world, giving 600 cubic yards output per hour.

D. WHITAKER,
1, UNION STREET, LEICESTER. 7906

T. & R. LEES, LTD., *Engineers,*

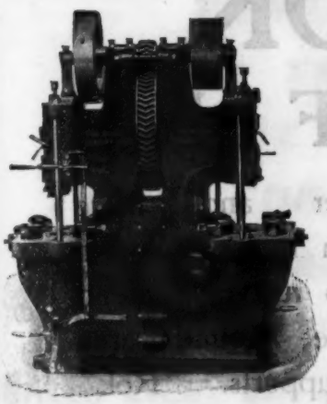
Telegrams—Lees, Hollinwood.
Telephone—16 Failsworth, Manchester. 448 Oldham.

HOLLINWOOD.



Motor-driven Saw Bench.

WOODWORKING MACHINERY FOR
Sawmills.
Shipyards.
Engineers.
Builders.
Cabinet Makers.
Wheelwrights.
Casemakers. 7626



PRESSES, SHEARS, PUMPS,
SHEET LEVELLING MACHINES.
8309

THE
PLECK FOUNDRY CO.,
LIMITED,
Telegrams: "Foundry."
Telephone: 492.
WALSALL.

"WOODITE,"

The Best Material for GAUGE GLASS RINGS & STEAM PACKINGS
For Valves, Joint Rings, Pump Cups, Ram Rings, Packing Rings and Sheeting.
In all Sizes and Sections.

Contractors to H.M. Government, Admiralty, War Office, Post Office, India Office, and the Colonial and Foreign Governments.

The Best Material for all High Pressure Steam or Electrical Installations.

PRICE LIST AND FULL PARTICULARS ON APPLICATION TO— 8980

WOODITE COMPANY,
Mitcham Common, Surrey, Eng.
Tel. Address: "Woodite, Mitcham." Telephone No.: Mitcham 1502

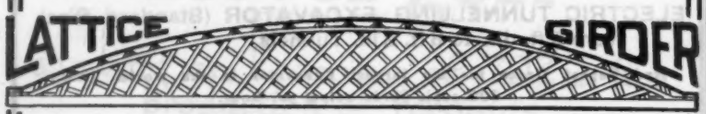
BRITISH
KROMHOUT MARINE OIL ENGINES
The Ideal Power for Tugs, Barges, Coasters.
WE are now in a position to accept orders at reasonable delivery for:
4 M 5 Type 260 B.HP. 4 M 6 Type 320 B.HP
Kromhout Oil Engines.

PERMAN & Co., Ld., 82-3, FENCHURCH ST., LONDON, E.C. 3
Telephone: Avenue 3256. Telegrams: Apermaco, Phone, London

AGENTS—Glasgow, DOUGLAS PRIMROSE & CO. 45, Hope Street; British Guiana, PSAILA BROTHERS, George Town, Demerara; Burma, BURN & CO. LTD. Rangoon; Calcutta, BURN & CO. LTD. Howrah Ironworks; Liverpool, S. C. CHAMBERS & CO. 3, King Street; Southampton, DAY, SUMMERS & CO. LTD. Northam Ironworks; Madras, BURN & CO. LTD.; Mauritius, TAYLOR, SMITH & CO. Port Louis; Montreal, A. J. JONES, P.O. Box 1422; Newcastle-on-Tyne, J. MACINDOE, 24, Dean Street; Newcastle (Australia), H. THURLOW & CO. Newcastle, New South Wales; New Zealand (North Island), BROWN & SONS, Te Kopura; South-West India, DARRAGH, SMAIL & CO. LTD. Alleppey. 8877

THE RED HAND TRADE MARK.

Anderson's "BELFAST" ROOFS



COVERED WITH

"ROK" ROOFING

Cheaper, lighter and more durable than iron roofs, acid and alkali proof. No rust to contend with. A large ground area without centre supports. "Rok" Roofing completely renovated by coat of "Rok" Mastic.

ILLUSTRATED CATALOGUE POST FREE ON APPLICATION.

D. ANDERSON & SON, LTD.,

Dept. 8, Lagan Felt Works, BELFAST

AND

Roach Rd. Works, Old Ford, LONDON, E.

Permac In Powder Form JOINTING MATERIAL

The Jointing that adjusts itself to the Job.

It does not matter how rough or pitted the faces of pipe flanges are, you can make a thoroughly satisfactory joint quickly and easily if you use "PERMAC." This moulds to the surface irregularities of the two opposing members and forms a permanently leaktight and rustless metal-to-metal joint, that will withstand the highest pressures and temperatures. Pressure may be turned on immediately the joint is made.

Get a tin to-day, and try it on your most awkward joint—it will never want re-making.

6341

E.I.H.

THOMAS & BISHOP,
LIMITED,
37, Tabernacle Street,
London, E.C. 2.

CARELS

DIESEL & STEAM ENGINES

Diesel Oil Engines—Drop Valve and Uniflow Steam Engines.

(GHENT, BELGIUM)

These well-known Slow Speed Diesel Engines and Heavy Steam Engines can now be supplied to all parts of the world.

All communications should be addressed to the London Office:

HEATH & SERENA,
Carlton House, Regent Street,
Waterloo Place, London, S.W. 1.

Telephone: Regent 3484. Telegrams: Dieselben, Piccy, London.

8128

(TRADE MARK.)

"TEXO"

DEPENDABLE ENGLISH OAK-TANNED

LEATHER BELTING

FOR

HEAVY MACHINE TOOLS,

MAIN DRIVES

AND

TEXTILE MACHINERY.

HYDRAULIC LEATHERS.
OIL DRESSED VALVE HIDES.

RAW-HIDE MALLETS, HIDE-FACED HAMMERS.

"PLEXUS" ROUND GUT MACHINE BANDING.

All kinds of Technical Leathers used in Mining, Engineering, Ship-building, Iron and Steel Making and Textile Trades.

E. J. COOKE, TRINITY LEATHER WORKS, BLACKFRIARS, MANCHESTER, 8513

Telegrams: "HIDES, MANCHESTER" Telephone: CENTRAL 1544

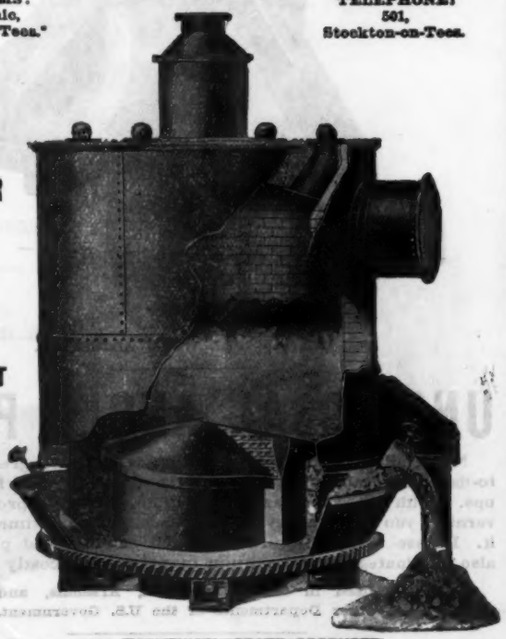
POWER MOND GAS HEATING

TELEGRAMS: "Tetratomic, Stockton-on-Tees."

TELEPHONE: 501, Stockton-on-Tees.

GAS PRODUCER PLANTS WITH AND WITHOUT BYE-PRODUCT RECOVERY.

MOND AND LYMN SYSTEMS.



MECHANICAL GRATE PRODUCER. 8226

THE POWER-GAS CORPORATION, LTD.,

PARKFIELD WORKS, STOCKTON-ON-TEES.

LIQUIDATION

OF THE

Automobile Depot

AT

ROMORANTIN (Loir let Cher),

By Messrs. C. PARROT.

FRENCH and AMERICAN SUPPLIES at the CAMP de PRUNIERS.

LORRIES of all classes,
TANK LORRIES,
SMALL LORRIES,
TRAILERS,
TANK TRAILERS,
SPARE PARTS,
TYRES FOR TROLLIES,
&c., &c., &c.

SALES EVERY DAY AT AGREED PRICES.

Immediate Delivery from the Camp de Pruniers.

(There is a Motor Service to Romorantin for Visitors attending the Sale).

Apply for further particulars—

P. RIQUIER,
Directeur General des Ventes-Renseignements
15, Rue Castellane, Paris (VIII e).
Telephone—Louvre 52-58.

Or—

M. FAVEROT, 8939
Directeur des Ventes au Camp de Pruniers.

JOHN FOWLER & Co. (LEEDS) LTD.

Steam Plough Works,

LEEDS.

London Office: 113, CANNON STREET, E.C. 4.

Branches and Agencies in every part of the World.

CULTIVATING MACHINERY,

Cable Systems: Tractors: Motor Ploughs.

ROAD TRANSPORT MACHINERY

Traction Engines: Road Locos.: Wagons.

ROAD MAKING MACHINERY,

Steam Rollers: Scarifiers, Sprayers.

LIGHT RAILWAY MACHINERY,

Plant, Locomotives and Rolling Stock.

8450

8338

LIGHT DRAFT SHIPBUILDERS

Hartness
Flat Turret Lathe

The single spindle Flat Turret Lathe for chuck and bar work; the double spindle machine for chuck work only.

: QUICK : DELIVERY

May we have your orders now?

8459

JONES & LAMSON MACHINE CO.,

9 and 10, Water Lane,
Queen Victoria Street,
LONDON, E.C. 4.

Telephone—722 City. Telegrams—Turretorum, Cent.

13 in. by 18 in. WORM ADJUSTING.

UNIVERSAL ANGLE PLATE

No detail of Machine manufacture is receiving greater attention to-day than labour saving and the elimination of haphazard set ups. With the Universal Angle Plate, which is provided with a vernier, you can set any angle to 5 min. in the time taken to say it. Its use insures accuracy as well as increased production. It also eliminates the necessity in many cases of costly jigs.

Used in the Navy Yards, Arsenals, and other Departments of the U.S. Government.

8840

MANUFACTURED BY

BOSTON SCALE & MACHINE COMPANY,

BOSTON, MASS., U.S.A.

Sole Agents for Great Britain, ALFRED HERBERT Ltd., COVENTRY.

FERRO ALLOYS

Ferro Chrome.
Low Carbon Ferro Chrome.
Ferro Tungsten.
Ferro Molybdenum.
Ferro Silicon.
Low Grade Ferro Silicon (12 %)

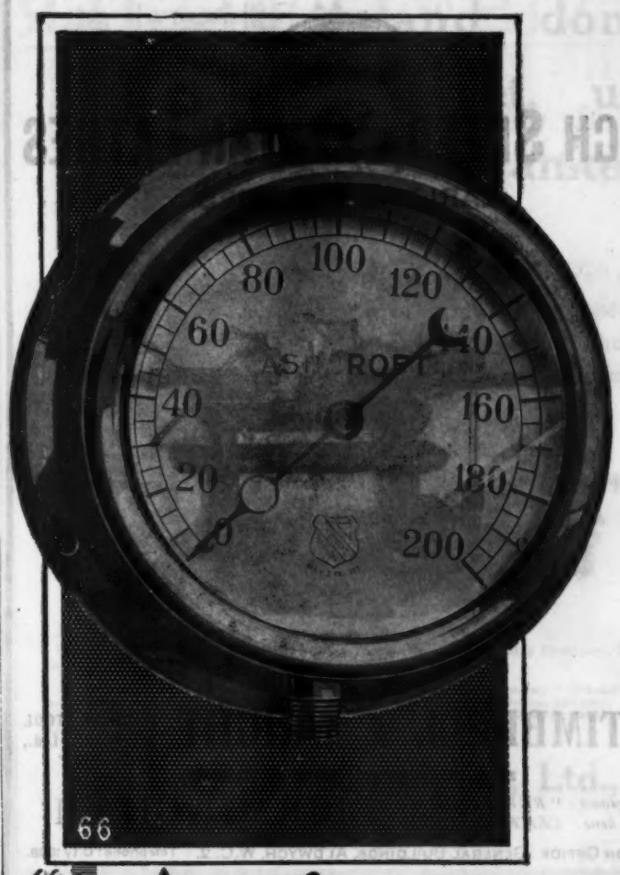
CARBON ELECTRODES.

Actual Manufacturers—

THE NEWCASTLE ALLOY CO. LTD.,
MILBURN HOUSE,
NEWCASTLE-ON-TYNE.

8791

Telephone—800 CITY, NEWCASTLE-ON-TYNE (7 lines).
Telegrams—"ALLOY," NEWCASTLE-ON-TYNE.



66

Ashcroft Gauges

Ashcroft Gauges are made in every type for indicating pressure, vacuum, or both, in a complete range of sizes to meet every requirement of European Engineers.

Their design and construction is based upon 75 years' experience in the manufacture of gauges and they are made by skilled workmen, of the finest materials.

Dials are graduated in kilograms, scale and connections are Metric Standard. Cases may be had of cast or drawn brass, drawn steel or cast iron. The drawn steel cases have a dull black finish which retains its handsome appearance for a long time in hard service.

Our agents who are listed below, carry complete stocks of Ashcroft Gauges and can make quick deliveries. They also carry stocks of Metropolitan Injectors and Consolidated Safety Valves for small and portable boilers.

MANNING, MAXWELL & MOORE, Inc.,
NEW YORK.

REPRESENTATIVES: 8497

ENGLAND.
CRANE-BENNETT, LTD., 45/51, LEMAN STREET, LONDON, E. 1.

SCOTLAND.
PHILIP & BRUCE, LTD., GLASGOW.

France.
MARET & Co. (Paris) LTD., 107, Avenue Parmentier, Paris.

Belgium.
A. A. KAMPFRATH (Brussels) LTD., 88, Rue de la Caserne, Bruxelles.

Italy.
MARET & Co. (Milan) LTD., Via Alessandro-Alessandri 2, Milan.

MMM-8g

SLOTTING.

MACHINES FROM 3 in. to 72 in. STROKE.

MELLOY'S PATENT STROKE CHANGE.

PUSH BUTTONS CONTROLLING:— STARTING, STOPPING, RAM-SETTING (UP or DOWN), STROKE CHANGING.

QUICK POWER MOTION TO SLIDES.

RHEOSTATIC BRAKE FOR QUICK STOPPING.

MUIR

8156

TELEGRAMS— "BRITANNIA," MANCHESTER.

TELEPHONE— 529 CITY.

T&W

HIGH SPEED CAPSTAN LATHES

EARLY DELIVERIES.

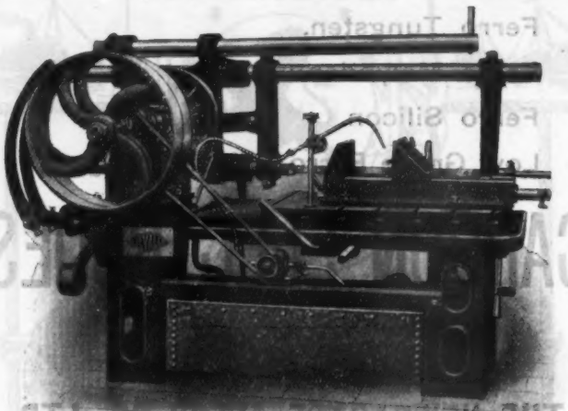
THE TIMBRELL & WRIGHT MACHINE TOOL & Eng. Co., Ltd.,
SLANEY STREET,
Telegrams: "REVOLVING."
Tele hone: CENTRAL 3723. BIRMINGHAM.
LONDON OFFICE: GENERAL BUILDINGS, ALDWYCH, W.C. 2. Telephone: City 1988.

VILVALLE

HEAVY DUTY

SAWING MACHINES

Guaranteed to Cut
DEAD SQUARE and in PERFECT ALIGNMENT



Capacity: No. 1 Size up to 20 in. by 12 in.
„ 2 „ „ „ 12 in. by 12 in.

Can we send you a Catalogue?

W. A. WALBER & Co.

38, Victoria Street, WESTMINSTER.
Telegrams: Vilvalle, London. 8592 Telephone No.: 3190 Victoria (2 lines)

HAMPTON & BEEBEE, LTD.

WEDNESBURY,
SOUTH STAFFS.
for

WASHERS

of every description, and
IN ALL METALS
for
AIRCRAFT, MOTOR AND ENGINEERING TRADES.

SHAFTING COLLARS
HACKSAW MACHINES
HACKSAW BLADES

BRIGHT STEEL BOLTS, NUTS and STUDS.
SQUARE HOLE GRUB SCREWS.
BRIGHT STEEL STRIP. 6526

Telephone— 80 WEDNESBURY.
Telegrams— "WASHERS, WEDNESBURY."

ARMSTRONGS & MAIN, Ltd.

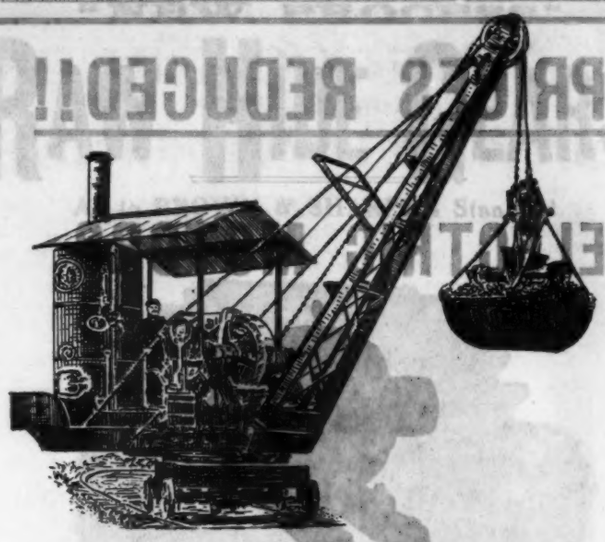
Sir W. G. Armstrong Whitworth & Co., Ltd. (Engine Works), and A. & J. Main & Co., Ltd.
GENERAL & CONSTRUCTIONAL ENGINEERS,

DESIGN & CONSTRUCT STEEL BUILDINGS

OF ALL TYPES
FOR ERECTION AT HOME OR ABROAD

LONDON BRANCH - - - AUSTRALIA HOUSE, STRAND, W.C. 2.
GLASGOW BRANCH - - - - - - - 149, WEST GEORGE STREET.
ALSO AT NEWCASTLE-ON-TYNE, MANCHESTER, EDINBURGH, DUBLIN, BOMBAY, CALCUTTA, CAPE TOWN AND JOHANNESBURG. 6675

We shall be pleased to forward our Illustrated Catalogue, No. 250, 1920 Edition, to Mine Owners, Manufacturers, Merchants, etc., interested in Steel Structures.



THE PRIESTMAN STEAM - GRAB
for handling
ALL BULK MATERIALS. 8813

PRIESTMAN BROS. LTD., HULL.

LONDON:
28, Victoria St., S.W. I.

MIDDLESBROUGH:
Lloyds Bank Chambers,

CARDIFF:
Albert Chambers, High St.

GLASGOW:
65, Great Clyde St.

N.P.S.

"—and don't forget, use Bowranite!"

Wherever there's steel or ironwork exposed to rust or corrosion, the up-to-date Engineer specifies

"Bowranite"
Guaranteed Rust Preventive

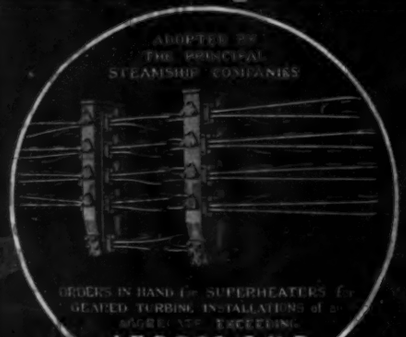
The brilliant, black, anti-corrosive enamel.

Losses from rust that "Bowranite" would prevent are enormous. Mining Structures, Bridges, Galvanised Iron Buildings, Iron Ships and Docks, go to rack and ruin.

Oil and lead paints cost more than "Bowranite" and do less. When you buy "Bowranite," it is not so much enamel and solvent that you buy, but safety for your costly iron and steel. Sample of "Bowranite," the proved rust preventive, with full particulars of scientific tests under all conditions, free on request.

Robert Bowran & Co., Ltd.,
4, St. Nicholas' Buildings,
Newcastle-on-Tyne. 8380

The "Robinson" Marine Superheater



ORDERS IN HAND for SUPERHEATERS for GEARED TURBINE INSTALLATIONS of MORE THAN EXCEEDING
150,000. S.H.P.

WRITE FOR FULL PARTICULARS

THE SUPERHEATER CORPORATION LTD.
14 New Burlington Street. London, W.1.
Telegrams: Locovapor, Phone, London Telephone: Gerrard 3822

Aldrich Pumps

FOR GENERAL SERVICE.

Cut illustrates a 12 in. by 12 in. Vertical Triplex delivering 1000 U.S.G.P.M. against 100 lb. pressure. Can be arranged with herring-bone gear drive or with pulleys for belt. Made in a wide range of sizes. :: Write for a set of "Pump Data." 9037

THE ALDRICH PUMP COMPANY,
Allentown, Pa., U.S.A.
British Agents: GILLESPIE & CO., Leadenhall Bldgs., 2, Whittington Avenue.

LUNTS OF LEICESTER

IN STOCK

OUR 8-INCH SENSITIVE BENCH

DRILLING MACHINE.

CAPACITY ½-inch.

The Substitution of Machine Cut Bevel Gears in place of the usual open Belt Drive, gives marked advantages in even such a small machine—

BEVEL GEARS — RACK BUSH and pinion are all cut from the solid and are interchangeable—

Weight of Machine 62 lbs. nett.
,, Crated 80 lbs.
Outside Dimension of Crate 20-in. × 32-in. × 9½-in.

PRICE (without chuck) £8 16s.
F.O.R. LEICESTER (Crates Extra).

Full Specifications of our 8-in. and 13-in. Bench, Also 16-in. and 21-in. Pillar Machines on request. 8646

Telephone: 3779 Central. Telegrams: "Tools, LEICESTER."

LUNTS LIMITED — LEICESTER

PRICES REDUCED!!

ELECTRIC MOTORS

8766

HIGGS (HB) BROS
ELECTRIC MOTORS

TELEPHONE: CENT. 944. TELEGRAMS: HIGBRO.

SAND PITS, BIRMINGHAM.

DO YOU GET OUR MONTHLY MAGAZINE?

GUNMETAL - CASTINGS -

for

PROPELLER SHAFT, STERN TUBE and PUMP

LINERS, SHELLS

for

PAPER MACHINE ROLLS, and MANGLE BOWLS, &c.

CASTINGS UP TO 5 TONS (ROUGH OR MACHINED).

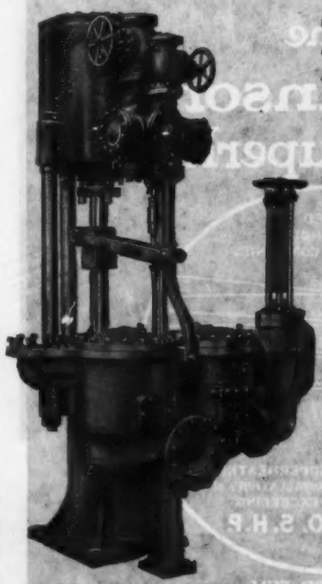
VICTORIA BRASS FOUNDRY CO. LTD.

BONNINGTON ROAD, 8210

WIRES: SHELLS, EDINBURGH. **EDINBURGH.** 'PHONE: LEITH, No. 288.

MARINE & LAND PUMPS.

OUR SPECIALITIES ARE STRONG and COMPACT IN DESIGN — OF BEST MATERIAL and WORKMANSHIP — EFFICIENT and RELIABLE IN SERVICE



DAWSON FEED PUMP.

THE **"DAWSON"** PATENT DIRECT-ACTING
FEED PUMPS, AIR PUMPS, SERVICE PUMPS.

IMPROVED DUPLEX PUMPS
VERTICAL or HORIZONTAL
TO SUIT ALL PRESSURES.

MOTOR DRIVEN PUMPS
FOR
DIESEL ENGINES, LAND STATIONS, MINE PUMPS.

8215

DAWSON & DOWNIE, LTD.

Telegrams— "PUMPS, CLYDEBANK." **CLYDEBANK.** Telephone— 55 & 56 CLYDEBANK

"NEW PROCESS"

RAW HIDE GEARS.

All to BROWN & SHARPE'S Standard.

Also METAL GEARS.

SEND FOR DESCRIPTIVE CATALOGUE.

GEORGE ANGUS & CO., Ltd.,

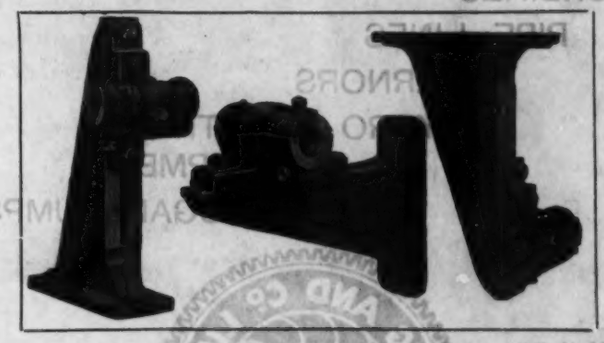
NEWCASTLE-ON-TYNE. 8234

SAVE YOUR POWER
LABOUR AND OIL
BY USING

FINNEY'S RIGID

SELF-OILING BEARINGS

TELEPH. ... MID. 839 AND 1970.
TELEG. ... TENTH, BIRMINGHAM.



ALL ADJUSTABLE. 8129

Floor Stand, Bracket and Hanger Bearings.

GEORGE FINNEY & Co BERKLEY ST.,
NEW EAGLE ENGINEERING WORKS **BIRMINGHAM.**

Manufacturers of Everything for the Transmission of Power.

INDUCED DRAFT

PRAT PATENTS, WITH FAN
"IN CIRCUIT" or "OUT OF CIRCUIT."

ESTABLISHED 1896.

GRAND PRIX—TURIN, 1911. GHENT, 1913.

Birmingham Corporation Electricity. First Instalment.

OPERATING ON

BOILERS rated at 8696

3 MILLION HP.

HIGHEST EFFICIENCY. NO WATER-COOLED BEARINGS.

SOCIÉTÉ DES CHEMINEES LOUIS PRAT
A TIRAGE INDUIT
144 - 146, Avenue des Champs Elysees, PARIS.

British Representative—**S. UTTING**, M.I.Mech.E., A.M.I.E.E.,
82, Victoria Street, WESTMINSTER, S.W. 1.
TELE.: "UMPTEEN," SOWEST, LONDON. 'PHONE: VICTORIA 3694.

SUTCLIFFE FANS

EFFICIENTLY REMOVE DUST FROM GRINDING, POLISHING, GLAZING, EMERY WHEELS, &c.

to comply with Home Office and Factory Inspectors' requirements.

Write for our new Booklet containing photos of actual Installations or ask for a call from our local Engineer.

Sutcliffe Ventilating & Drying Co., Ltd.

Telephone No.— 3920 City
Cathedral Gates, MANCHESTER.
Telegraphic Address— Ventilabro.

8171

BOVING & Co.

for

WATER POWER PLANT

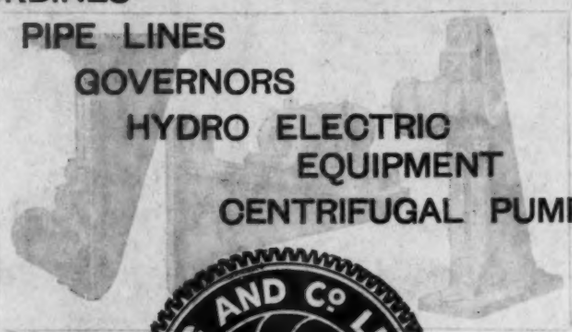
TURBINES

PIPE LINES

GOVERNORS

HYDRO ELECTRIC EQUIPMENT

CENTRIFUGAL PUMPS



BOVING AND Co LIMITED — J OB

Head Office:
56, Kingsway,
London, W.C.2.

Works:
STOKE-ON-TRENT

8913

The "BEE" GOVERNOR

(EASTWOOD'S PATENT)

for Maximum Production

The Governor is Isochronous: that is, in effect the Engine makes the same R.P.M. at any and every position of the Governor Sleeve without interference with any of the connections to the valve gear.

The engine is under Automatic control at full speed, at all loads, from the moment the sleeve moves on starting up.

The Value of Output of Factory is increased by

2 to 10%

Due to constant maximum speed maintained with full or reduced Boiler pressure and partially loaded Engine.

Less Wastage of Material.
Fewer Breakages.
Better Quality of products.
Fewer Stoppages of Machines.
Better Supervision by Attendants.
Can be lubricated whilst running.
All Parts Enclosed.
SENSITIVE. DURABLE.

THE "SYKES" PATENT

Flexible Reversible Insulating Coupling

(Patent No. 109362).

For coupling **Motors, Dynamos, Printing Machinery, Steel Rolling Mills,** and all kinds of **Machines** and **Shafts.**

Reduces **Breakages** due to **Vibration** and **Shock.** Reduces friction on **Shafts** wearing out of **Line.**

Allows Longitudinal Expansion. Will run in either **Direction.** Renewal of **Buffers** effected without dismantling of Shafts or **Machines.** Parts are **Electrically Insulated.** Has no **Springs.** Large range of **Flexibility** with full or **partial load.**

SIMPLE IN DESIGN. 8539

SOLE MAKERS: **NEWTON, BEAN & MITCHELL,**
Dudley Hill, BRADFORD.

Telegrams—"ABBOTT, DUDLEY HILL."
'Phone—125 (2 lines), Dudley Hill.

J. P. HALL & CO., LD.

Telegrams: "DYNAMO, OLDHAM." **OLDHAM.** Telephone: 300 (2 Lines).

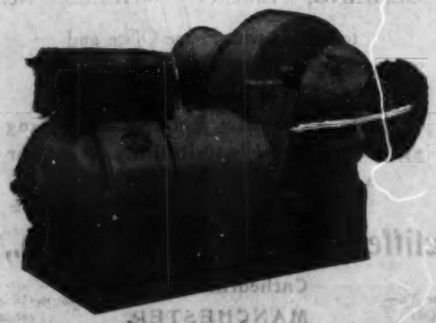
SHIPYARD ELECTRIC WINCHES

AS USED BY THE LEADING SHIPBUILDERS IN THE UNITED KINGDOM.

Made in Five Sizes with D.C. or A.C. Motors

TO PULL 1½ TO 15 TONS 50 FEET PER MINUTE

From Photo 5-ton WINCH.

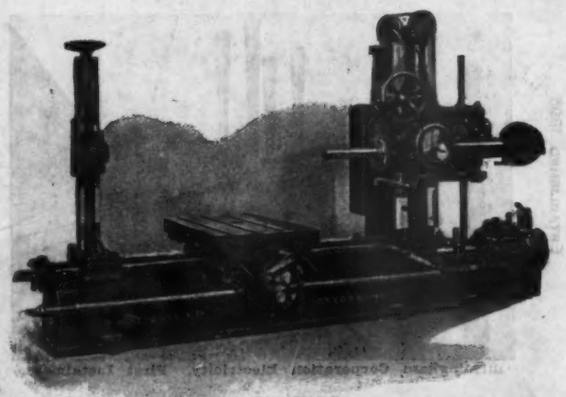


With D.C. MOTOR.

T755

Blackriding Iron Works, Werneth, OLDHAM.

Horizontal Drilling, Boring and Milling Machine.



A Heavy and Powerful General Purposes Machine. Spindle 3⅛ ins. diam., 24 ins. traverse. Six feeds to Spindle and 16 speeds through Change Gear Box.

Compound Worktable with ample traverses and milling feed.

Reasonable delivery. 8625

MACHINE TOOL MAKERS. **D. & J. TULLIS, Ltd.,** CLYDEBANK.

JOHN HANDS & SONS

POWER PRESSES

STYLE O.
DOUBLE-SIDED FORGING and CLIPPING PRESS
FITTED WITH
SIDE SHEARS

MADE IN EIGHT STANDARD SIZES SUITABLE FOR USE WITH HEAVY or LIGHT BATTERIES OF STAMPS.

Full particulars upon request.

HEAD OFFICES - - CARDIGAN WORKS,
BIRMINGHAM. 8363

WIRE: MACHINERY B'HAM." 'PHONE: CENTRAL 8232.

DIE-PRESSINGS
(SOLID)
IN BRASS.

ADVANTAGES—
SMOOTHNESS, UNIFORMITY, RELIABILITY, MACHINES FREELY.

BROOKES & ADAMS, LTD.
BARR STREET, HOCKLEY, BIRMINGHAM, ENGLAND. Tel.—28 North. Tel Add.—"Telaba." 7353
MAY WE ADVISE OR QUOTE YOU?

LANARKSHIRE STEEL CO., LTD.
MOTHERWELL.

ALL CLASSES OF STEEL SECTIONS
ANGLES
BULB ANGLES
CHANNELS
JOISTS
FLATS
ROUNDS
SQUARES
TEES
FORGING BLOOMS AND SLABS
TUBE STEEL
BRIDGE RAILS.

7 ROLLING MILLS

Telegrams—"Siemens, Motherwell." 7360
Phones—7 & 161 Motherwell; 8030 Central, Glasgow (direct wire to works).

If you are looking out for the PERFECT SYSTEM of storing ALL KINDS of Oil for daily use, you cannot do better than instal

Standard Sizes
5 to 50 Gallons.

"VALOR" Oil Cabinets.

No Waste. No Leakage. No Smell.

CAPACITY - - 50 30 20 12 6 gallons.
PRICES ON APPLICATION.

For use in Factories, &c., and Establishments where cleanliness and safety are considered.

The Valor Company, Limited,
Aston Cross, BIRMINGHAM 5624

We knock the "T" out of CAN'T

YOU often come up against a proposition which you are forced to regard as a commercial impossibility. You are asked to make a part, the formations of which are obviously taboo as far as the lathe or miller are concerned—a ratchet formation at the bottom of a hexagonal recess, for instance.

Do you realise that such formations can be quickly and quite easily produced as

DIE CASTINGS

We cut a die which is the negative of the required formation, and force in molten alloy under high pressure. Why not talk over the possibilities with us ?

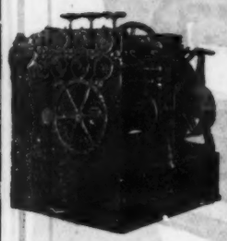
8392

THE PATENT DIE-CASTINGS CO., LTD.
64, Strode Road, Willesden Green, London, N.W. 10.
TELEPHONE . . WILLESDEN 733.

SPRING COILING
— AND —
WIRE COILING MACH'Y

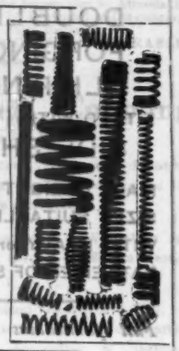
of every description and for every purpose.

For instance, our UNIVERSAL SPRING COILERS (built in eight sizes, to handle oil-tempered wire from ·004 in. diam. to ⅜ in. diam.) will produce, without requiring any other equipment than that furnished with each machine, any or all of the spring forms illustrated herewith.



Patented.

We offer to— THE
PROFESSIONAL SPRING MAKER
more than
FORTY STANDARD MACHINES
and numerous special ones.



SLEEPER & HARTLEY, INC. WORCESTER, Mass., U.S.A.

AGENTS AND REPRESENTATIVES.

U.K.: P. A. PERRY, 68, Queen Victoria Street, London, E.C. 4. 8204
France: EDGAR BLOXHAM, 12, Rue du Delta, Paris. Italy: H. COB & CLERICI, Milan.
Australia and New Zealand: EDWIN WOOD PTY., Ltd., Melbourne.
South Africa, India, China, Japan, South and Central America and Mexico:
AMERICAN STEEL EXPORT CO., OF NEW YORK.

THIS HAMMER STRIKES AUTOMATICALLY
100 BLOWS PER MINUTE

BRETT Patent Automatic Friction Drop Hammer.

2½ cwts. to 4 cwts. weight of head.

Operated by Drop-Forger.

No driver necessary.

FOR BELT OR MOTOR DRIVE.

WE SUPPLY COMPLETE EQUIPMENT FOR PRODUCING DROP-FORGINGS

ASK FOR CATAL. No. 1400.

800

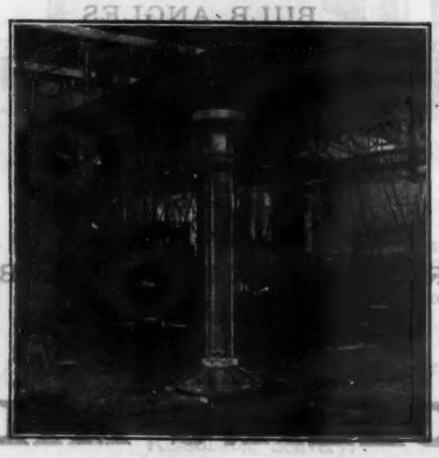
BRETT'S PATENT LIFTER Co. LTD
FOLESHILL WORKS, COVENTRY. ENGLAND.

THE BUTTERLEY CO., Ltd.
DERBY. ESTABLISHED 1791.

Telephone—Nos. 14 and 76, RIPLEY. Telegrams—"IRONWORKS, BUTTERLEY."

Pig Iron, Bar Iron, Iron Castings
Up to **20** Tons.

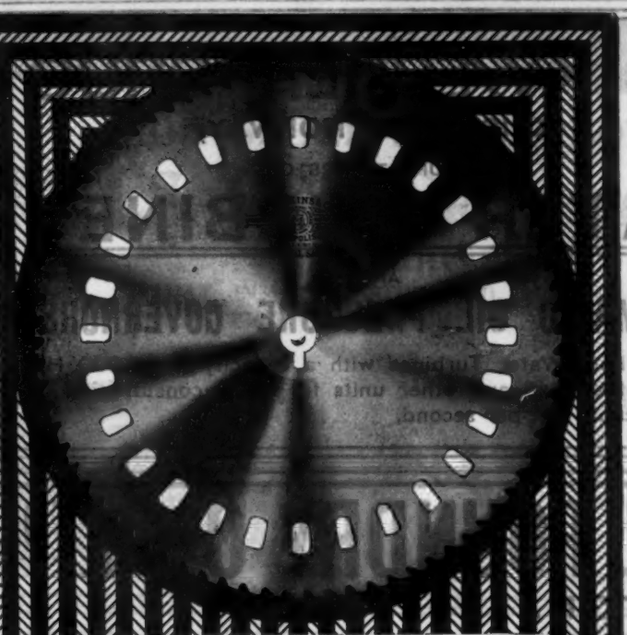
Bridge and Structural Steelwork, Pit Trams, &c.
High-Class Machine Work of all descriptions.



8818

Special Acid-Resisting Metal for Chemical Plants.
Large Retorts, Pans, Acid Eggs, &c., a Speciality.

LONDON OFFICE—52, Queen Victoria Street. Telephone—7180 Gerr.



ATKINS SAWS—that's enough.
Saws to fit all styles and makes of machines.

E. C. ATKINS & COMPANY, Inc.
INDIANAPOLIS, INDIANA, U.S.A.
Represented by
JOHN SHAW & SONS, WOLVERHAMPTON Ltd.
WOLVERHAMPTON, ENGLAND,
and PARIS BRANCH HOUSE
10 RUE GUSTAVE FLAUBERT PARIS, FRANCE.

TWENTIETH CENTURY STRUCTURAL STEEL.

By the recent consolidation of our Norwich Works we are now able to make quick deliveries of highest class structural steel for Works Additions, Chemical Factories, Foundry Structures as well as Steel-framed Buildings.

Every inch of Boulton & Paul Steel construction has behind it the reputation of over a hundred years' practical experience in the Design, Manufacture, and Erection, working of iron and steel on a Quality Basis for all Industrial Needs.

DELIVERY.

Our Works possess good water frontage. We can make direct shipments F.O.B. to London, Liverpool, Hull, Antwerp and other ports. Our whole Works are always open for inspection to all who are interested.

The above illustration shows a B & P Steel Building, designed, manufactured and erected by us. The Building is 240 ft. long, 62 ft. high, 50 ft. span (over all) and the total floor area is 48,000 square ft. Owing to the nature of the Building special arrangements were made to design to suit erection, each floor being completed and prepared for use whilst other work above was proceeding. The floors and columns are of a specially heavy nature designed to carry heavy loads.

Telegrams Boulton Norwich **Boulton & Paul Ltd.** *Telephone Norwich 851*
Works and Head Offices, NORWICH.
London Address: 135-7, Queen Victoria Street, E.C. 4. 8797

CHURCHILL
SMALL TOOLS
of all kinds & varieties to suit your needs

WE are agents for Brown & Sharpe Small Tools and Norton Grinding Wheels, and we hold stocks of

Jacob Drill Chucks
Micrometers and Centre Drills
"Flexio" H.S. Lathe Tools
Cards, Taps and Dies
Firth's Files
Armstrong Tools
Geometric Die Heads and Taps
"Novo" H.S. Drills
Millers Fallo To ls
"Comet" H.S. Milling Cutter

Let us quote, We can deliver at once

CHARLES CHURCHILL & Co. LIMITED
9-15 LEONARD STREET LONDON, E.C.2.
BIRMINGHAM MANCHESTER GLASGOW
NEWCASTLE-ON-TYNE BRISTOL LEEDS SHEFFIELD

ARCHIBALD EDMESTON & SONS, LIMITED.
PATRICROFT.

PATENT FRICTION CLUTCH.
300,000 HP. IN SUCCESSFUL OPERATION.
INVALUABLE FOR DRIVING:

Mining Machinery & Haulage
Saw Mills,
Electric Light and Power.
Concrete and Brick-making Machinery, Flour Mills, Textile Machinery, and Mine Gearing Generally.

FOR STARTING GAS & OIL ENGINES.

FOR COUPLING SHAFT-ENDS

NOTE: **GENERAL MACHINE PLANING UNDERTAKEN FOR THE TRADE.**

Capacity of Machine, 6 ft. by 6 ft. by 22 ft.

Casing of 4200 HP. Vertical Water Turbine. 9304

A/S KVÆRNER BRUG

KRISTIANIA, NORWAY,

MANUFACTURERS OF

WATER TURBINES

AND

AUTOMATIC OIL PRESSURE GOVERNORS.

We have built Water Turbines with a capacity of 15,000 HP. for 2600 feet head and other units for water consumption up to 2000 cubic feet per second.

HOLCROFT'S STEEL FOUNDRY Co., LTD.,

BILSTON.

STEEL CASTINGS FOR LOCOMOTIVES, MOTOR VEHICLES, CRANES AND GENERAL ENGINEERING WORK.

PROMPT DELIVERY: GUARANTEED TESTS. 9397

Commercial Office:
329, HIGH HOLBORN,
LONDON,
W.C. 1.

TRAMWAY AND WAGON WHEELS A SPECIALITY.

Telegrams:
PITTEVIL, HOLB, LONDON.

Telephone:
1887 HOLBORN.

Contractors to Railways

Contractors to Marine Engineering

Govt. Contractors

Economise by Annual Contracts

TRADE MARK

FOR

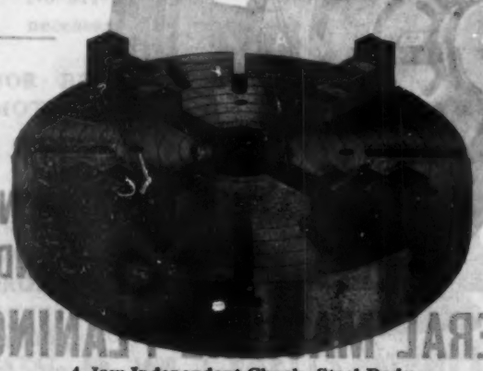
ANTI-FRICTION METAL AND DIE CASTINGS

YOUR safeguard as well as ours.

THE ATLAS METAL & ALLOYS CO., LTD.

52, Queen Victoria Street, LONDON, E.C. 4.

Telephone: CITY 4841. Telegrams: "ALOYAU, CANNON, LONDON." 8731



4-Jaw Independent Chuck, Steel Body, for Heavy Duty.

Strong Chucks—

That truly describes Skinner Steel Body Independent Lathe Chucks. They are not only strong and powerful, but wonderfully accurate. The

SKINNER Steel Body Independent Lathe Chuck

is a single steel casting of great strength, well proportioned and accurately finished. Face is graduated accurately in inches. Screws and bearings are made of the toughest steel to withstand abnormally hard wear.

The dependability of Skinner Steel Body Independent Lathe Chucks is conclusively proved by the fact that not one has ever been known to break in service—and we have been making them for many years.

Write for catalogue and illustrated literature.

THE SKINNER CHUCK COMPANY

NEW BRITAIN, CONN. U.S.A.

ESTABLISHED 1887.

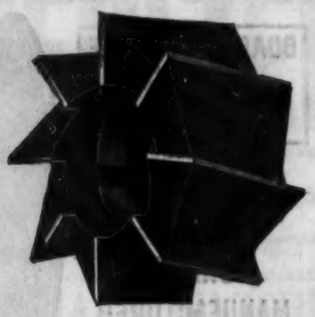
London Office:—139, Queen Victoria Street, London, E.C. 4. 9047

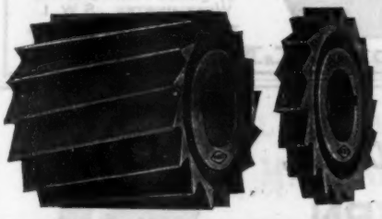
HIGH SPEED and CARBON, TWIST

DRILLS, REAMERS and CUTTERS

Quality Tools

THAT INSURE FASTER AND BETTER FEED WITH GREATER PRODUCTION AND LESS REGRINDING.





Write for our Catalogue "C."

WILT TWIST DRILL COMPANY OF CANADA, LTD.

WALKERVILLE, ONTARIO, CANADA.

REPRESENTATIVES:

NEW YORK CITY
Mr. W. H. SADLER,
1465, Broadway, New York City, U.S.A.

AUSTRALIA and NEW ZEALAND:
Mr. D. MOLDEN,
P.O. Box 1349, Sidney, N.S.W.

8888

SOUTH AFRICA:
Mr. ELLIS STENT,
Port Elizabeth, South Africa.

THE REES ROTURBO MFG. CO., LTD.

Head Office and Works: WOLVERHAMPTON, ENGLAND.

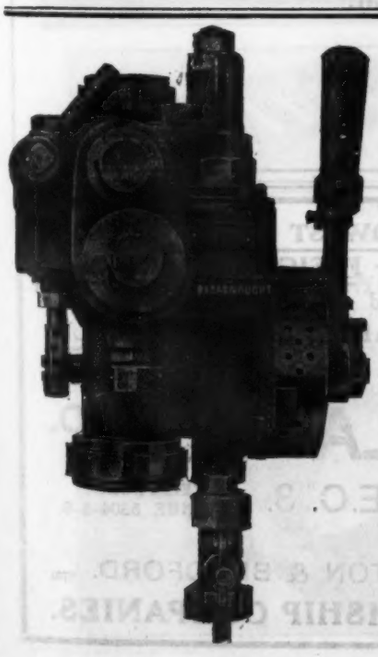
HIGH EFFICIENCY MINE PUMPS.

Rees Roturbo High Lift Pump with D.C. Motor,
15,000 G.P.H 1000 ft. Head. 1440 R.P.M.

London Office—
HASTINGS HOUSE,
NORFOLK STREET,
STRAND, W.C.

Tel. 930, Wolverhampton.
1511 Central, London.

8563



THE DREADNOUGHT EJECTOR

GRESHAM PATENT. *SELF REGULATING.*

Requires no complicated Steam Reducing Valve.
Works at any boiler pressure with ONE setting of the steam valve.
Vacuum Automatically maintained constant.
GREATLY INCREASED CAPACITY.
ECONOMY IN STEAM CONSUMPTION.
Rapid production of vacuum.
Power to maintain a good vacuum against leakage.
Simplicity of construction.
Interchanges with our Standard Type "C" Ejector.
Works down to 90 lbs. pressure.

8179

THE VACUUM BRAKE CO., LTD.

3-5-7, Old Queen Street, Westminster, London, S.W. 1.

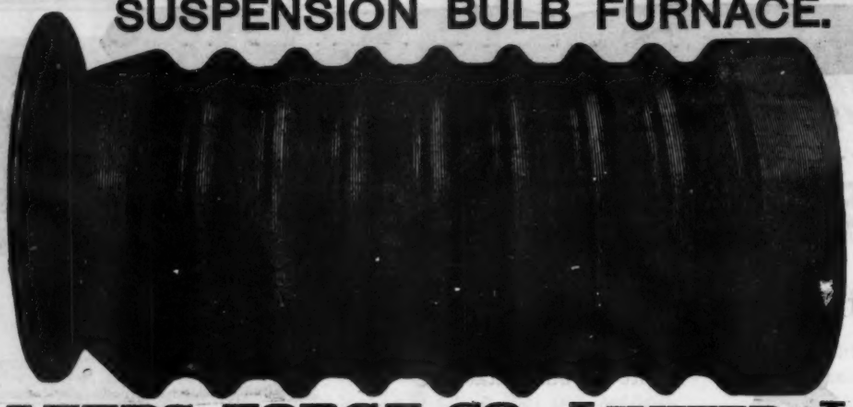
Telegraphic Address: Solution Vic, London. Telephone: Victoria 3269.

SUSPENSION BULB FURNACE.

BOARD OF TRADE
CONSTANT FOR SUSPENSION BULB FURNACE
510.

The STRONGEST FURNACE MANUFACTURED.

GREATEST DIAMETER OF FURNACE EVER OFFICIALLY TESTED TO COLLAPSE.



PATENT.

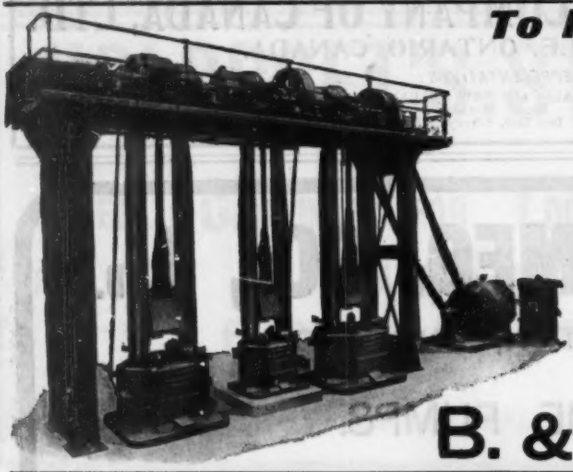
BOARD OF TRADE
HIGHEST CONSTANT FOR OTHER CORRUGATED TYPES
480.

HIGHEST FACTOR of SAFETY.

UNIFORM THICKNESS.

LONDON OFFICE:—
3, QUEEN ANNE'S GATE, WESTMINSTER, S.W. 1.
Tels. Address:—Elmvos, London.

THE LEEDS FORGE CO., LIMITED, LEEDS.



To Increase Output and Decrease Cost,

USE OUR MODERN

HAMMERS AND STAMPS

8229

B. & S. MASSEY, LTD., MANCHESTER.

NEWCASTLE SHIPBUILDING CO., LTD.,

Telegraphic Address: "Watertight, Hebburn."

HEBBURN-ON-TYNE.

Telephones. Hebburn 83. " 84. " 85. " 86.

BUILDERS OF PASSENGER, CARGO AND OIL TANK STEAMERS.

Licensees to Build under the ISHERWOOD SYSTEM.

Capacity of Shipyard:
Ten BUILDING BERTHS up to 550 feet.
RIVER FRONTAGE, 1,500 feet.

8841

EXPORT ORDERS

LOWEST TERMS QUOTED for FREIGHT INSURANCES and PASSAGES to all PARTS of the WORLD.

PLACE YOUR SHIPPING BUSINESS WITH

McGREGOR, GOW & HOLLAND LTD.

TELEGRAMS: "KASTWARDLY." 1 & 4, FENCHURCH AVENUE, LONDON, E.C. 3. TELEPHONE: AVENUE 5304-5-6.

And at MANCHESTER, LIVERPOOL, HULL, CARDIFF, SOUTHAMPTON & BRADFORD. 8701

LOADING BROKERS TO MANY OF THE PRINCIPAL STEAMSHIP COMPANIES.

THE PATENT LIGHTNING

CRUSHER & PULVERIZER

The Best on the Market for reducing hard materials such as Flint, Shingle, Gravel, Silica, Magnesite Barytes, etc.; also Limestone, Chalk, etc.

TELEGRAMS:— "AGENCIADOR, LONDON."
TELEPHONE:— 4656, CITY.

Invaluable for CONCRETE and BUILDING SAND. 7174

THE PATENT LIGHTNING CRUSHER CO., Ltd., 14a, Rosebery Avenue, LONDON, E.C.

TIME CHECKING MACHINES. TIME RECORDERS. WATCHMAN'S WATCHES.

BRITISH MADE.

1B Class, Patent Card Recordar.

GEARS
ALL DESCRIPTIONS
MACHINE CUT
AND
MACHINE MOULDED.

Watchman's Watch.

REDUCING
AND
MULTIPLYING
GEARS
IN OIL TIGHT CASES.

O. 17 Class, Patent Diagram Recorder. 8644

PRICES AND PARTICULARS ON APPLICATION.
LLEWELLAN'S MACHINE CO., BRISTOL, ENG.

RESPONSIBLE AGENTS WANTED WHERE NOT REPRESENTED.
Telegraphic and Cable Address—"LLEWELLIN'S BRISTOL."

HASLAM'S

Ammonia & CO_2 Compression Systems
Ammonia Absorption, Compressed Air

REFRIGERATING MACHINERY

FOR COLD STORAGE, ICE-MAKING, &c., ON SHIPBOARD AND ASHORE

541-8, SALISBURY HOUSE, LONDON WALL, LONDON, E.C. 2.

THE HASLAM FOUNDRY & ENGINEERING CO., LIMITED,
INCORPORATED WITH
PONTIFEX & WOOD, LIMITED. 01448

UNION FOUNDRY, DERBY.
Telegrams—ZERO DERBY.

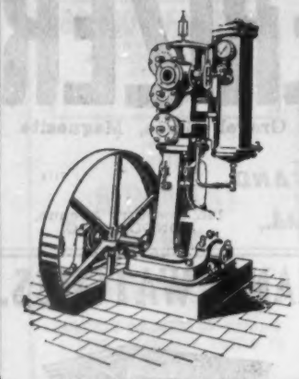
STEEL CONVEYOR BAND

FOR

COLD ROLLED STEEL BANDS OF GREAT FLEXIBILITY IN ONE PIECE LENGTHS UP TO 300 FT.

Conveyor units & installations, to cleanly & efficiently deal with — WARM or COLD MATERIAL — ranging from — COAL — COKE — CLAY — FOUNDRY SAND — CHEMICALS, etc., to FOOD STUFFS — Obtain designs and estimates. 8645

FROM STEEL BELT CONVEYORS LTD
NORWICH UNION CHAMBERS
BIRMINGHAM
TELEGRAMS "SIMPLICITY" BIRMINGHAM



COMPRESSORS

FOR ALL PRESSURES UP TO 2800 LBS. PER SQUARE INCH.

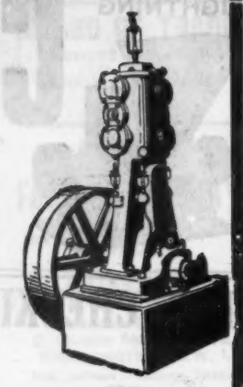
VACUUM PUMPS

FOR ALL PURPOSES.

Prompt delivery of standard sizes. Write for catalogues and list of users.

Burckhardt Engineering Works,

Works—Basle, Switzerland. 9012 26, Victoria Street, S.W. 1.



THE LEEDS FORGE CO., LTD., LEEDS.

PIONEERS in the Design & Manufacture of PRESSED-STEEL UNDERFRAMES & BOGIES, and ALL-STEEL RAILWAY PASSENGER CARRIAGES and WAGONS.

LONDON HOUSE— 3, QUEEN ANNE'S GATE, WESTMINSTER, S.W. 1.

UGANDA RAILWAY.

8203 Covered Goods Wagon, with Fox's Pressed Steel Underframe and Bogies, and Lane's Patent Corrugated Pressed Steel Doors.

HUDSWELL, CLARKE & CO., LIMITED,

RAILWAY FOUNDRY, LEEDS.

LOCOMOTIVES

For Main or Branch Railways, Contractors, Ironworks, Collieries, &c. Made to suit any Gauge of Railway.

Established 1860.

Telegraphic Address: LOCO, LEEDS.

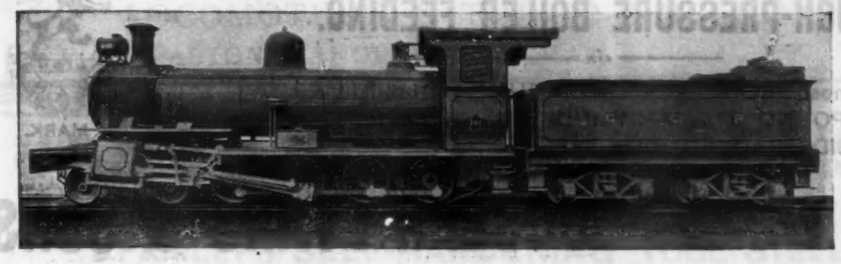
1188

PRICES, PHOTOGRAPHS AND FULL SPECIFICATIONS ON APPLICATION.

SOLE MAKERS OF "RODGERS' PULLEYS" (REGISTERED).

WROUGHT IRON THROUGHOUT, RIM, ARMS, AND BOSS.

R. & W. HAWTHORN, LESLIE & CO., LTD.



LOCOMOTIVES

Of every description for Home and Foreign Railways.

TANK ENGINES AND COMBINED CRANES AND LOCOMOTIVES

ALWAYS IN STOCK AND IN PROGRESS.

For Collieries, Ironworks, Railway Depots, Branch Lines, Contractors, &c.

Telegraphic Address: LOCOMOTIVE, NEWCASTLE-ON-TYNE. ESTABLISHED 1817.

MARINE ENGINEERS AND SHIPBUILDERS. **NEWCASTLE-ON-TYNE.** 8204

YORKSHIRE ENGINE CO., LTD.,

Head Office: MEADOW HALL WORKS, SHEFFIELD.

Contractors to Admiralty, War Office, India Office, Colonial and Foreign Governments, and Leading Shipbuilders.

LOCOMOTIVES OF ANY GAUGE OR WEIGHT.
IRON & STEEL FORGINGS. WELDLESS STEEL RINGS.
SHIP & ENGINE DETAILS. W.T. SLIDING SCUTTLES.
SOLID & BUILT-UP CRANKSHAFTS. PROPELLER SHAFT NUTS.
WATERTIGHT DOORS. CRANE POSTS & HOOKS.
BOAT DAVITS. RUDDER POSTS & PINTLES.
ELECTRIC WINCHES. GENERAL MACHINE WORK.
COMPLETE SETS OF ENGINE SHAFTING.

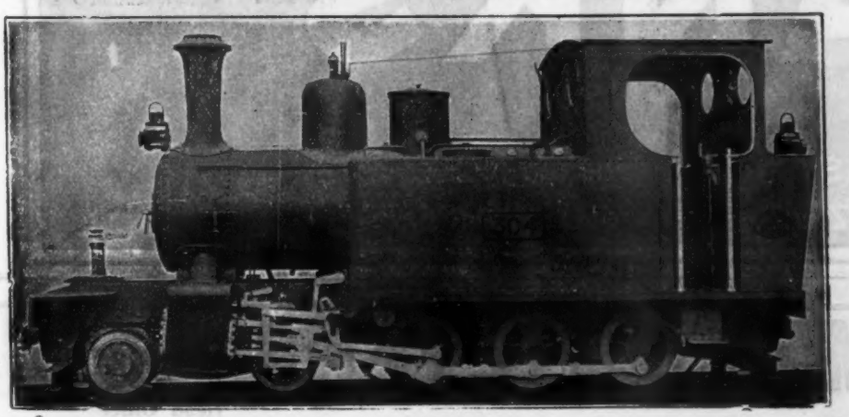
Telegrams:—ENGINE, SHEFFIELD. Telephones:—129 & 130 Attercliffe. 8287

London Office : : : : 15, CAXTON HOUSE, WESTMINSTER.

THE HUNSLET ENGINE CO., LTD.

LEEDS.

MAKERS OF



LOCOMOTIVE ENGINES

Adapted to every variety of work and gauge.

DESIGNS AND SPECIFICATIONS supplied or worked to.

QUOTATIONS AND SPECIFICATIONS ON APPLICATION.

Telegraphic Address—"ENGINE, LEEDS."
Telephone—No. 20877 (3 lines). 9019

PECKETT & SONS, LTD.,

BRISTOL.

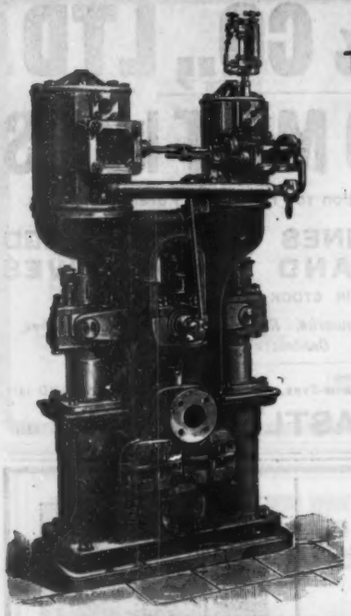
Telegrams . . . . Peckett, Bristol.

SPECIALITY

TANK LOCOMOTIVES

Of all Descriptions and any Size or Gauge

Full Particulars on Application. 8013



THE "BEAM" PUMP FOR TRADE

HIGH-PRESSURE BOILER FEEDING.

The most ECONOMICAL FEED PUMP yet brought out.
COMPOUND STEAM CYLINDERS.
OUTSIDE PACKED RAM TYPE.

LION MARK

CATALOGUE NO. 3 ON APPLICATION.

JOSEPH EVANS & SONS
(WOLVERHAMPTON) LTD.
CULWELL WORKS—
WOLVERHAMPTON.
Telegrams:—"EVANS, WOLVERHAMPTON."

LONDON:—Salisbury House, London Wall, E.C. 8911

ESTABLISHED 1793

NEWTON, CHAMBERS & CO. LTD.
THORNCLIFFE IRONWORKS & COLLIERIES.
NEAR SHEFFIELD.

TANKS

IN CAST IRON OR STEEL
OF ALL SIZES FOR ALL PURPOSES.

On Admiralty and India Office Lists.

THE CLEMENT STEVENS PNEUMATIC ENGINEERING CO., LTD.,

Telephone—Victoria 850.
Telegrams—"PNEUCLESTE, SOWEST, LONDON."

Head Office
28, SPENSER STREET, BUCKINGHAM GATE, WESTMINSTER, S.W. 1.

STEVENS-HUNTER PNEUMATIC HAMMERS
FOR RIVETTING, CHIPPING, CAULKING, ETC.
HAMMER TYPE HOLDERS ON.
PLAIN HOLDERS ON.

EFFICIENCY
SIMPLICITY
DURABILITY

ALL BRITISH

NO SKILLED ATTENTION NEEDED
UPKEEP COSTS NEGLIGIBLE.

THE DISTRIBUTING VALVE OF THIS HAMMER DOES NOT REQUIRE LUBRICATION.

THE BEST FOR EXPORT

8695

Managing Director— C. H. Stevens.

AGENTS:
Newcastle-on-Tyne.—T. W. CUNNINGHAM & Co., Ltd., 7, Collingwood St. *Lancs. and Yorks.*—G. CURTIS HOLT & Co., 2, Basinghall Sq., Leeds. *Scotland.*—LINDSAY CROOKSTON & Co., Ltd., 163, Hope St., Glasgow. *Birmingham.*—S. R. CLAY, Esq., 57, Pershore Street, Birmingham. *South Wales Area.*—W. A. KING, Esq., Downend House, Downend, Bristol. Telephone: 21, Staple Hill, Bristol. *South West Area.*—F. R. C. WORSLEY, Esq., Ottery St. Mary, Devon. *Ireland.*—MASON ALCOCK, Esq., Windsor Buildings, North St., Belfast. *France.*—Messrs. BURTON FILS, 68, Rue des Marais (Bould. Magenta), Paris. Telegrams: "Utilitas, Paris." Telephone: Nord 27-23. *Switzerland.*—T. EDGAR HARLEY, A.M.I.E.E., 3, Seehofstrasse, Lucerne. Telegrams: "Harley, Lucerne." Telephone: 4.53 Lucerne.

TUBES LIMITED

WELDLESS TUBES for BOILERS and STEAM PIPES
LOCOMOTIVES & THE ENGINEERING & MOTOR TRADES.

Works: ASTON MANOR, BIRMINGHAM. 3651

Tele{grams: CYLINDERS. phone: No. 871 & 872 E (4 lines).

JAMES FAIRLEY & SONS, LTD.,

Contractors to His Majesty's and other Governments.

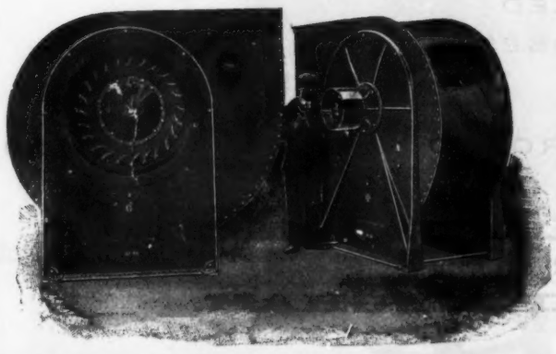
General Steel Manufacturers and SPECIALISTS in TOOL STEELS

Invite attention to their Unrivalled Self-Hardening Steel.

FAIRLEY'S SELF-HARDENING TOOL STEEL, for Heavy Cuts at High Speeds,

is considered to be the HARDEST and TOUGHEST Steel yet made (although the Cheapest in the Market). Small samples free to approved buyers.
NOTE.—JAMES FAIRLEY & SONS, Ltd., Works (Bramall Lane, SHEFFIELD, & Mill St. Forge and Rolling Mills, BIRMINGHAM) are merely Branch Departments and
☞ *All Communications should be addressed to the Head Offices*—OLD MINT, SHADWELL STREET, BIRMINGHAM. Od 1719

FOR ALL PURPOSES.



TRADE MARK

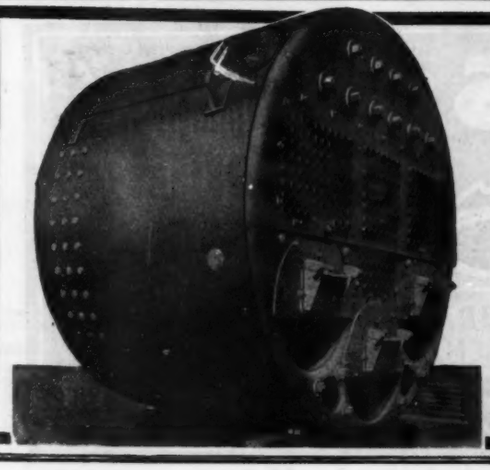
FANS & BLOWERS

STANDARD & OSWALD STOTT (Engineers), LTD.,
Evington Valley Road,
LEICESTER.

Telegraphic Address "BLOWING, LEICESTER." Telephone Nos.: 4761-2-3 LEICESTER.

MANCHESTER · GLASGOW · NEWCASTLE-ON-TYNE.

20 years' experience is at your service for the asking. 8372



THE FORTH SHIPBUILDING AND ENGINEERING CO. LTD.

LINDSAY BURNET'S

MOORE PARK BOILER WORKS.
GOVAN, GLASGOW.

MAKERS OF
MARINE BOILERS.
WATER-TUBE BOILERS.
DRY-BACK BOILERS. 9014
MULTITUBULAR UNDERFIRED BOILERS.
OIL FUEL INSTALLATIONS. SUPERHEATERS.

LONDON OFFICE:—VICKERS HOUSE, BROADWAY, WESTMINSTER, S.W. 1.

Telegrams:—BURNET, GLASGOW.

McKIE & BAXTER

ENGINEERS, SHIPBUILDERS, BOILERMAKERS, COPLAND WORKS, GLASGOW.

Telegrams: "CALIDAD, GLASGOW." Codes: A 1, A B C, Engineers and Private Code

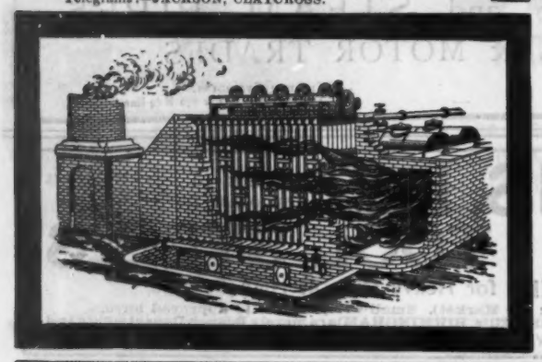
8390

SPECIALITY.—MACHINERY FOR VESSELS CONSTRUCTED ABROAD.

Correspondence Invited.

The Clay Cross Company, Ltd., Clay Cross, Derbyshire.

Telegrams:—JACKSON, CLAYCROSS. — ESTABLISHED 1837. — Telephone:—479 CHESTERFIELD.



MAKERS OF STANDARD-TYPE

FUEL ECONOMISERS

For Utilising the Waste Heat from Steam Boilers of all Types. 8747a

SAVES IN COAL FROM 15 TO 25 PER CENT.

Adopted by Steam Users throughout the World.

BRIGHT

COLD ROLLED FOR ALL PURPOSES.

DRAWN HEXAGON & ROUND

STEEL

BRITISH ROLLING MILLS, LIMITED,
Cliveland Street,
BIRMINGHAM. 8760

TELEgrams—"OCTAGON."
Phone—Central 1869, 1870.

HOWELL'S FILES

TRY SWING

LARGE CONTRACTORS TO THE ADMIRALTY INDIA OFFICE AND WAR OFFICE.

LONG LIVED FILES OF FINEST QUALITY & DURABILITY.
FILES & RASPS OF EVERY DESCRIPTION.

HOWELL & Co LTD. Brook Steel Works, SHEFFIELD.

LOCKWOOD & CARLISLE, Ld.

EAGLE FOUNDRY, SHEFFIELD.

Telegraphic Address: "PISTON, SHEFFIELD." National Telephone: 1276.

Improved Double-action Metallic Piston Packing Rings & Springs.

CARLISLE'S PATENTS.

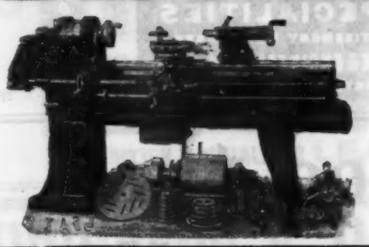
Improved Double-action Piston Valve Rings.

SPECIAL FACILITIES FOR QUICK DESPATCH OF URGENT ORDERS.

As Fitted in S.S. "BRITANNIC."

H.P. Rings and Springs specially designed for High Steam Pressures.

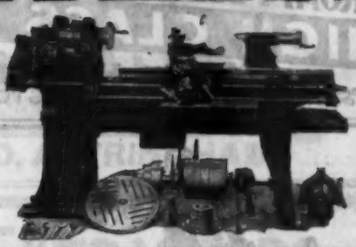
DRUMMOND —— LATHES.



well built, accurate and well finished.

Write for full particulars. 8385

DRUMMOND BROTHERS LTD.,
ENGLE WORKS, GUILDFORD.

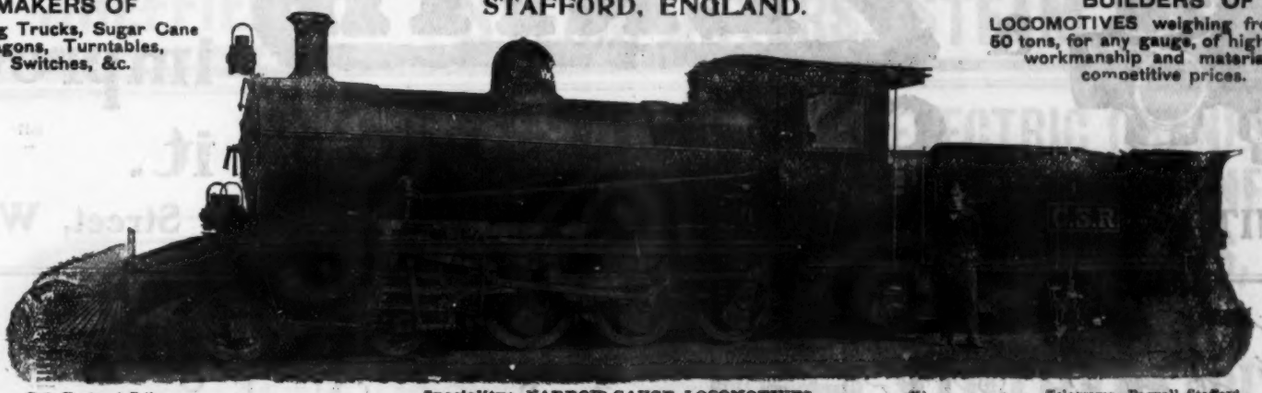


W. G. BAGNALL, LTD.,

STAFFORD, ENGLAND.

MAKERS OF
Tipping Trucks, Sugar Cane Wagons, Turntables, Switches, &c.

BUILDERS OF
LOCOMOTIVES weighing from 3 to 50 tons, for any gauge, of highest-class workmanship and material, at competitive prices.



Code Used —A B C. Speciality:—NARROW-GAUGE LOCOMOTIVES. 681 Telegrams: Bagnall, Stafford.

HYATT

(TRADE MARK)

Roller Bearings

Suitable for all Machinery

HYATT Ltd.,
4, Thurloe Place, South Kensington, London, S.W. 7.
'Phone: Kensington 3143 (2 lines). Wires: Hydrolim, Southkens.

THE DELTA METAL CO., Ltd.,

DELTA WORKS, EAST GREENWICH, LONDON, S.E. 10
(And at Dartmouth Street, Birmingham.)

FOUNDED 1883. INCORPORATED 1888.

High-class Engineering Alloys:

STRONGEST MALLEABLE BRONZES, ACID-PROOF and other CORROSION-RESISTING METALS.

(Registered Trade Mark) **"DELTA" BRAND** (Registered Trade Mark)

BRASS, YELLOW METAL, NAVAL BRASS, BRONZE, COPPER, WHITE METALS, &c.
RODS, SHEETS, TUBES, WIRE, CASTINGS, FORGINGS, STAMPINGS.

ORIGINAL AND LARGEST MANUFACTURERS OF

EXTRUDED BARS

Bars of any Section in Brass, Bronze, Red Metal, Yellow Metal, Naval Brass, Copper, &c.

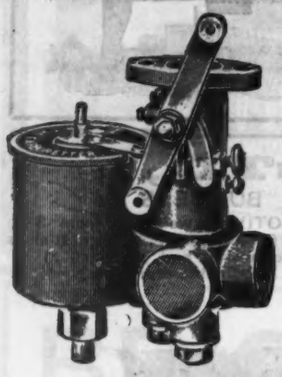
HIGH-SPEED TURNING AND SCREWING BRASS.

Bronze and Brass Forgings to Admiralty and other tests and specifications. 8478

On the Lists of the ADMIRALTY AIR MINISTRY, WAR OFFICE, MINISTRY of MUNITIONS, INDIA OFFICE, POST OFFICE, CROWN AGENTS for the COLONIES, &c.

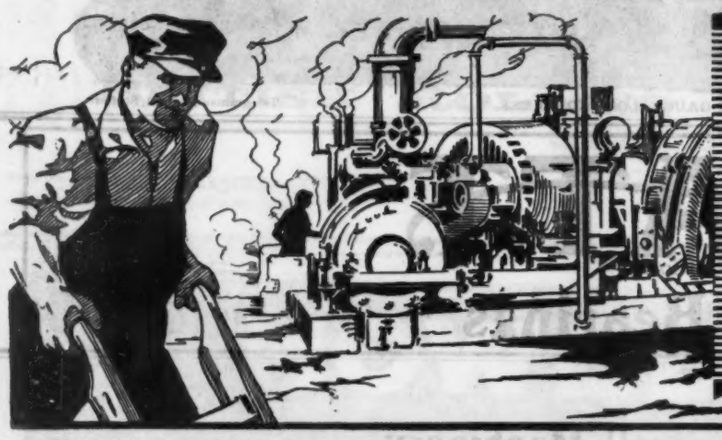
PROMPT DELIVERY OF
HIGH CLASS CASTINGS
FOR ENGINES, MOTORS, PUMPING GEAR, &c.
FROM ENGINEERS' DRAWINGS OR PATTERNS.
ROE & HARRISON LTD.
Globe Foundry, STORES ROAD. DERBY.
ON ADMIRALTY AND WAR OFFICE LISTS.

CROSBY SPECIALITIES.
SEE ADVERTISEMENT NEXT WEEK.
CROSBY VALVE & ENGINEERING Co., Ltd.
147 QUEEN VICTORIA ST., LONDON, E.C.
8734



No car is so good that a ZENITH will not improve it.
Carburetter
8517

Send for Booklet.
ZENITH CARBURETTER CO., LTD., 40-42, Newman Street, W. I.
Telephone: Museum 4812-4813.



We are the Largest Buyers of Non-Ferrous
SCRAP METAL
and are always open for
SCRAP BRASS, GUN METAL, COPPER, TURNINGS & BORINGS ETC. ETC.
H. B. BARNARD & SONS
CLYN STREET, VAUXHALL, LONDON, S.E. 11.
Telephone: HOP 4520.
Telegrams: "METALCIBLES" LONDON.
8511

100-TON LADLE CRANE.

CRANES
FOR
STEELWORKS
SHIPYARDS
DOCK AND WHARVES.

"TEMPERLEY" TRANSPORTERS
FOR LOADING, UNLOADING, AND DISTRIBUTING COAL.

SIR WILLIAM ARROL & Co LTD PARKHEAD, GLASGOW.
(Agents in New Zealand—Messrs. COREY-WRIGHT & SALMON, Wellington, N.Z.)
88

ADMIRALTY WAR DEPT AP.

HYDRAULIC LEATHERS

THE BRITISH SPECIALISTS LEATHERS COMPANY (ALTRINCHAM) LIMITED, ALTRINCHAM 9026

PRINCEPS & Co., SHEFFIELD.

LONDON OFFICE: 64, VICTORIA STREET S.W.1.

AIR FILTERS. OIL EXTRACTORS. STEAM DRYERS. STEAM TRAPS.

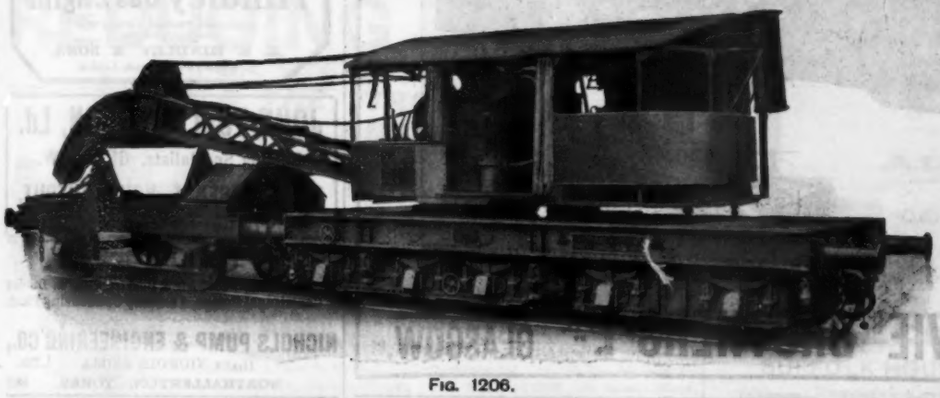


Fig. 1206.

ELECTRIC CRANES, STEAM CRANES, CAPSTANS, GRABS, &c.

STOTHERT & PITT LIMITED, BATH.

REPRESENTATIVES: Oct 8307

Messrs. Richardson McCabe & Co., Wellington, N.Z. Coates & Co. Pty., Ltd., Melbourne, Australia; Peacock Bros., Montreal, and Vancouver, Canada.

H. MUNZING, LIMITED,

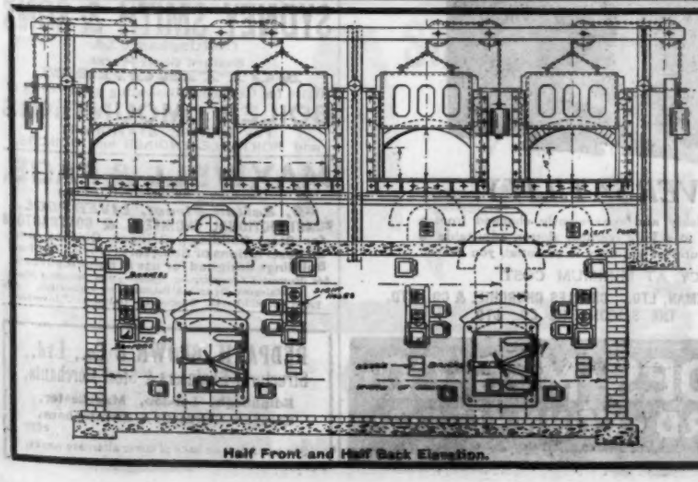
90 to 96, UNION STREET, LONDON, S.E. 1.

SOLE AGENTS for (Dept. E.G.)

WALWORTH MANUFACTURING CO., BOSTON.

THE GENUINE WALWORTH STILLSON WRENCH

Is superior to any other Pipe Wrench in Four essential details— STRENGTH, DURABILITY, QUICK ADJUSTMENT, RAPIDITY OF ACTION. Be sure the Wrench bears the above Trade Mark.



Half Front and Half Back Elevation.

SOLID FUEL FURNACES.

One of the many types of Coke-fired Muffles and Furnaces constructed for the processes of :—

Annealing, Case Hardening, Hardening, Enamelling, Heat-Treating, etc., etc.

SOLID FUEL FURNACES FOR

Billet-Heating, of hearth and continuous types, Coal-fired.

Melting Furnaces for Brass, and other non-ferrous alloys, with self-contained coke-heated Regenerator.

Melting furnaces for Lead and Spelter.

Special Furnaces designed and specifications sent on request.

Gas Furnaces for all Heat Treatment requirements. 8047

RICHMOND FURNACES

(The Richmond Gas Stove & Meter Co., Ltd.)

Works & General Offices : Grappenhall, WARRINGTON.

Offices . . . . . 164-172, Queen Victoria Street, London, E.C. 4.

Machine Tool Agencies Required.

We shall be pleased to receive particulars of new and attractive lines of labour-saving Machine-Tools, Small Tools, and Accessories with a view to taking up world-wide selling agencies for same

ALFRED HERBERT Ld.

COVENTRY. L347

BALANCING MACHINERY
Send for Booklet.
VIBRATION SPECIALTY CO.,
Philadelphia, U.S.A. 8876
European Representative—Mr. H. CAMPBELL, c/o American Chamber of Commerce, London.

GO TO THE
Farrar Boilerworks Ltd.,
NEWARK 8033
FOR BOILERS & RECEIVERS.
See full page advertisement other weeks.

HORDERN & MASON,
Engineers,
ST. MARY'S, BIRMINGHAM.
Specialists in Sheet Metal Working Machinery.
See displayed Advt. every fourth week.

CASTINGS.
British Engineering Firm established in France and Belgium with several foundries working under their supervision, can supply CASTINGS of all descriptions in ordinary or malleable iron, steel and aluminium. Plain or intricate work undertaken, and prompt delivery assured.
Quotations submitted on receipt of blue-prints or sketches.
CIE DES MOTEURS "NATIONAL," 32, Rue des Mathurins, PARIS. 8997

HARTNELLS'
Volt Works, Leeds, 889
Can Govern *your* Engines.

HUDSON Patent Cylindrical Water Tube BOILER
THOMAS HUDSON, LTD
SHEEDFORD BOILER WORKS, COATBRIDGE
8375 See Illustrated Advt. page 80, Dec. 17.

"SPLIT GRIP" COLLAR (TRIER'S PATENT)
AS USEFUL AS THE SPLIT PULLEY.
IN HALVES.
NO Set Screw to cause Accidents.
Grips like a Vice.
Fixed or Removed without Disturbance.
Sole Makers:
TRIER Bros.
98, VICTORIA ST., LIMITED, WESTMINSTER, LONDON, S.W. 1. 8456

MOTOR-DRIVEN "UNIVERSAL"
PORTABLE RADIAL DRILLING MACHINE
"An indispensable Machine for Locomotive Builders"

8737
DAVIE BROTHERS LTD. GLASGOW.

MACHINE VERSATILITY.
The one machine that can be quickly and conveniently changed from a horizontal shaper with a 7" stroke to a 3-1/2" vertical slotter, adjustable to 10 degrees. For light work where utmost accuracy is essential, you get
MAXIMUM EFFICIENCY AT MINIMUM COST.
FOR SALE IN ENGLAND BY—BUCK & HICKMAN, LTD., CHARLES CHURCHILL & CO., LTD. ALFRED HERBERT LTD., THE SELSON ENG. CO., LTD.

THE RHODES MFG. CO.
HARTFORD - CONN - U.

Rd. White & Sons, Widnes, Lancs.
FOR **RAILS,** 8743
POINTS AND CROSSINGS.
AERIAL ROPEWAYS.

The CLYDE STRUCTURAL IRON CO., Ltd.,
Clydeside Ironworks, Scotstoun, Glasgow.
MANUFACTURERS OF 7810
Iron & Steel Roofs, Buildings, Workshops, &c., &c.
LONDON OFFICE, 48, Cornhill, E.C.

ELECTRIC CONTROL LTD.,
Bridgeton, GLASGOW.
"Empire"
Automatic Controllers.
See Display Advt., page 12, Dec. 10. 8808

If you want a really simple and efficient engine, specify the
Hindley Gas Engine
High-speed, Enclosed Vertical type.
See List, post free. 2706
E. S. HINDLEY & SONS,
11, Queen Victoria Street, London.

JOHN TULLIS & SON, Ld.
Belting Specialists, GLASGOW. 7433
WILL INCREASE YOUR OUTPUT.
SEE ADVT. LAST AND NEXT WEEK'S ISSUE.

PUMPS.
Direct-acting, Feed, Air & Service Pumps, Duplex & Centrifugal Pumps, Auxiliary Condensing Plant.
NICHOLS PUMP & ENGINEERING CO.,
(LATE NICHOLS BROS.), LTD.
NORTHALLERTON, YORKS. 8877

CLIFTON & BAIRD, Ld.
Metal Sawing Machine Specialists,
EMPRESS WORKS, 8343
JOHNSTONE, SCOTLAND.

WALTER CRADDOCK
(Established 1864).
PLAIN AND ORNAMENTAL JAPANNING of all kinds of castings, &c.,
ALSO
GENERAL ELECTRO PLATING in NICKEL, and COPPER DEPOSITING in large or small quantities 8939
17 & 19, Brook Street, London Road, Manchester.

TURNBULL'S SAFETY STOP CHECK, STRUCK & REDUCING **VALVES**
Stand for Cock Cover
ALEX. TURNBULL & CO. LTD.
GLASGOW.

SYDNEY SMITH & SONS
(Nottingham), Ld. 8830
Basford Brass Works,
NOTTINGHAM.
Write for Catalogue illustrating great variety of
BOILER MOUNTINGS
For MARINE, STATIONARY and PORTABLE ENGINES and BOILERS.

MAXWELL & FAGE.
(Successors to BRUCE & STILL, LTD.)
48, Sefton Street, LIVERPOOL.
CONSTRUCTIONAL ENGINEERS & CONTRACTORS
for Steel Buildings, Bridges, Girders, and all descriptions of Structural Work. Timber Buildings designed for use at home & abroad.
See Illustrated Advertisement Preceding and Following Week.
Catalogues, Designs & Estimates on application. 8780
Tels.: No. 1617 Royal. Telegrams: "Galvanizer," Liverpool.

REDPATH, BROWN & Co., Ltd.,
Structural Engineers & Steel Merchants,
Edinburgh, London, Manchester, Glasgow, Newcastle & Birmingham.
8839
See our Advt. on back of cover alternate weeks.

WHEN SECONDS ARE PRECIOUS

THE

WESTINGHOUSE

BRAKE

HELPS TO HUSTLE,

not only by stopping trains in the shortest possible distance, but, by its prompt release, enabling them to restart as soon as desired.

THE WESTINGHOUSE BRAKE & SAXBY SIGNAL CO., Ltd.,
82, York Road, King's Cross, London, N. 1.

RAILWAY CARRIAGES
RAILWAY WAGONS
TRAM CARS, ETC.

MIDLAND
RAILWAY-CARRIAGE
& WAGON CO. LTD.
MIDLAND WORKS,
WASHWOOD HEATH
BIRMINGHAM.

LONDON OFFICE:
14, VICTORIA STREET,
WESTMINSTER, S.W.1
TELEPHONE:-
No: 3371, VICTORIA
TELEGRAMS:-
UNDERFRAME, VIC, LONDON.

TELEGRAMS, "WAGON" BIRMINGHAM
PHONE, No 485-4-5 EAST.

THE MASON
REDUCING VALVES
FOR STEAM OR AIR
HOLD THE FIRST PLACE—
THE POSITION OF MERIT
Simple, Self-contained.
Best Material and Workmanship.

They reduce and maintain an even steam or air pressure regardless of the initial pressure.

SEND FOR CATALOGUE. Od 2535

The Mason Regulator Co., Boston, U.S.A.

LONDON: 147, Queen Victoria Street,
COPENHAGEN: Gothersgade 155.
ANTWERP: 33, Rue des Peignest
SYDNEY: 74, Clarence Street.
MELBOURNE: 435, Bourke Street.

THERMOMETERS
RECORDING.

0° to 1800° Fah.

ALL TYPES.

CAPILLARY TUBING,
Up to 50 yards from Source of Heat.

ENGINEERING SUPPLIES, LTD.
SUFFOLK HOUSE, 5, Laurence Pountney Hill, E.C. 4.
Telegrams: "PROELLS, LONDON." 8706 Telephone: CITY 2930

1855 - CRANE - 1920
World Wide

PIPE FITTINGS
Sizes ⅛ in. to 6 in. for All pressures and All Purposes.

VALVES & COCKS
Their Economy meets the needs of to-day. Their Permanent Quality provides for the future.

"Everything for any Pipe Line."

CRANE-BENNETT LTD.
Distributors of Sanitary Fixtures and Materials,
45-51, Leman St., London, E. 1. 8174
Telephone: Avenue 8062/5 (4 lines). Telegrams: "Spruceness, Phone, London."

'BITUFERRI'
For Structural Ironwork, War Vessels and Standard Ships, Holds, Bunkers and Hulls.

TRADE MARK
"SHELL" BRAND
REGISTERED.

'BITUFERRI'
Costs only half and is a better anti-corrosive than Red Oxide Paint.
SANCTIONED FOR USE BY GOVERNMENT INSTEAD OF LINSEED OIL PAINTS.

Sole Makers ARCHD. H. HAMILTON & CO.,
POSSILPARK, GLASGOW. 8436
Telephones: 3585 and 3586 Douglas.

SMITH BROS. & HILL, LTD., ALBERT SPRING WORKS WEST BROMWICH
— Contractors to the Admiralty, War Office, India Office, —
Crown Agents for the Colonies, English and Foreign Railways.
Phone: 136 Westbromwich. Tel. Add.: "SPRINGS."

The Valves, Cocks and Gun-metal Fittings Every Steamship Ought to Have

are supplied by a firm which has specialised in this class of engineering for over 30 years.

Made for strength and durability to resist the extraordinary hard wear and tear they are subjected to, they defy competition.

Although not low priced, their value is unquestioned and well worth any difference asked for lighter made fittings.

A sample order is far more demonstrative than quoting a price.

When next building or making renewals specify for our Valves, Cocks and Gun Metal Fittings.

GEO. CLARK & SONS,

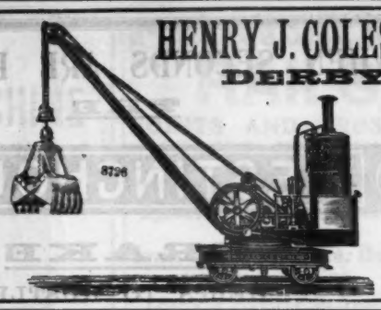
(HULL), Ltd. Estd. 1859.

Brass Founders, Coppersmiths, &c.

WATERHOUSE LANE, HULL.

M A A 8513

Makers of
Steam and Electric Travelling Cranes.
Overhead Electric Cranes.
Single and Double Chain Grabs.
Steam Crane Navvies.
Petrol and Oil Motor-driven Cranes.
Shunting and Breakdown Cranes.



HENRY J. COLES, Ltd.
DERBY.

Telegrams—"COLES, DERBY."
Telephone—1266 Derby.

ALEX. FINDLAY & CO., Ltd.,

Steel Roof and Bridge Builders, Structural Engineers, ... **MOTHERWELL, N.B.**

Contractors for all the Main Buildings for the FRANCO-BRITISH EXHIBITION, LONDON, 1908, covering a total area of 560,000 square feet; also for the Grand Stadium, area 200,000 square feet.

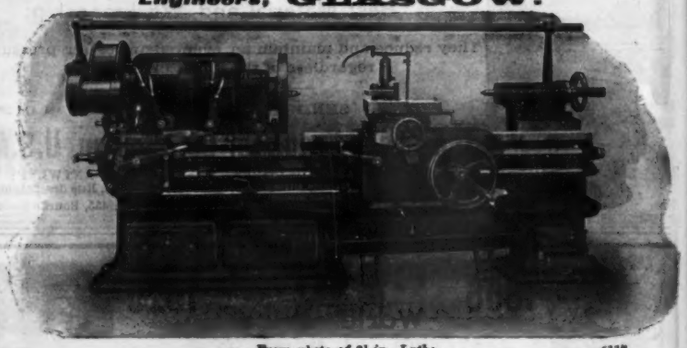
ALL KINDS OF STEEL STRUCTURES DESIGNED AND EXECUTED.
SPECIALITY:—HYDRAULIC PRESSED STEEL TROUGH FLOORING FOR BRIDGES AND BUILDINGS

Head Office . . . . . MOTHERWELL, N.B.
London Office . . . . . 9, VICTORIA STREET, S.W.

TELEGRAMS: FINDLAY, MOTHERWELL, PARKNEUK, LONDON

DEMPSTER, MOORE & CO., LTD

Engineers, **GLASGOW.**



From photo of 24 in. Lathe. 6117

SPECIALITY:—NEW TYPE LATHES FOR HEAVY CUTTING.

LIGHT STRUCTURAL WORK.

Steel Framed Motor Garage, 450 ft. long by 60 ft. span.

Designed, Constructed and Erected by

SMITH & PEARSON, Ltd.,

Albert Buildings, Queen Victoria Street, LONDON.

WRIGHT'S CALORIFIERS FOR EFFICIENCY.

SEND YOUR ENQUIRIES FOR:— CALORIFIERS OF ANY SIZE FOR ANY PURPOSE; FOR USE WITH EITHER LIVE OR EXHAUST STEAM

TO:—

WRIGHT'S FORGE & ENGINEERING Co., Ltd.

PHONE—32 Tipton. 6585 London Wall.
WIRE— "Forgings," Tipton. "Penetration," London.

TIPTON, Staffs. 08758
AND
57, Bishopsgate, LONDON, E.C.

Contractors to THE ADMIRALTY · WAR OFFICE &c.

BLUNDELL'S LONDON COPPER & BRASS WORKS (1910) Ltd

West India Dock Road, Limehouse, E. and Tilbury Docks, Essex.

COPPER WORK in EVERY BRANCH

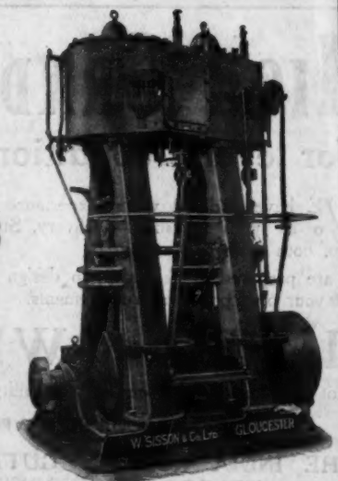
ENGINEERS · COPPERSMITHS · BRASS FOUNDERS · BRASS FINISHERS · PLUMBERS · COOKING UTENSILS TINNED & RETINNED WITH PURE TIN · HIGH-CLASS ENGINE & BOILER FITTINGS · CASTINGS IN BRASS, BRONZE, GUN METAL, COPPER, ALUMINIUM & ACID RESISTING METALS · MAKERS AND REPAIRERS OF BREWERS · DISTILLERS; MINERAL WATER MANUFACTURERS & CONFECTIONERS' PLANT · THE MAKING & REPAIRING OF COPPER REVOLVING PANS · COPPER TILT PANS, STEAM & HOT WATER JACKETED PANS & JAM FILLING MACHINES A SPECIALITY

Marine and General Repairers

'Phones: EAST 29 & TILBURY 33. Telegrams: "BLUNDELLS, FOR, LONDON"

ENGINES for PNEUMATIC ELEVATING PLANTS

With Patent Automatic Crankshaft Governor



W. SISSON & CO., Ltd.,
GLOUCESTER, ENGLAND.
TELS.—"SISSON GLOUCESTER." TEL.—No. 97. 8173

NOW READY.

THE PRACTICE OF LUBRICATION

By T. C. THOMSEN.

Consulting Oil Engineer; for many years Chief Engineer, The Vacuum Oil Company, Ltd., London; and recently Research Engineer, Anglo-Mexican Petroleum Co., Ltd.

610 pages, 6 × 9, 227 illustrations. 36s. net, post paid.

Since the subject of lubrication is so intimately connected with the mechanical and operating conditions of engines or machinery, the book presents for each type of engine and class of machinery the "technical background" necessary to focus the lubricating problems and to determine the character of the oils required to give the best service.

The book points out the conditions under which lubricants have to work for particular types of machinery and the influences to which they are subjected during use.

It gives helpful information for engine builders, mechanical and electrical engineers in charge of plant, and oil chemists and manufacturers.

Everyone interested in the saving of power through lubrication will find this book of great value.

Thirty-five chapters of sound, practical information on lubricating engineering.

McGRAW-HILL PUBLISHING CO., LTD.,
6, Bouverie Street, 8971 **London, E.C. 4.**

TERRY'S

are ready to quote for

Springs — washers — hoseclips — presswork —flexible shafts.

WE can interpret your wishes correctly—in a high grade service rendering quality, and give you supplies "perfect for their purpose."

On large contracts—calling for large deliveries, we can give advantageous prices—we welcome small orders too.

May we quote for your supplies?

HERBERT TERRY & SONS, Ltd.,
Manufacturers,
REDDITCH, Eng.
Est. 1855.

Telephone: 61 REDDITCH.

808. Folding Lever Clip holds letters, papers, cuttings, etc., securely. Arms lie flat on package if used in pocket.

	Length.	Jaw.	Price.
Midget	⅝ in.	¼ in.	2/6
No. 1	1¼ in.	½ in.	3/6
No. 2	1¾ in.	⅝ in.	6/-
No. 3	2 in.	1 in.	8/-

per dozen Bronzed.

BROUGHTON COPPER Co LD

WORKS: MANCHESTER AND DITTON (near Widnes).

COPPER SMELTERS COPPER AND BRASS MANUFACTURERS.
FLUID-COMPRESSED HYDRAULIC-FORGED
COPPER, BRASS AND BRONZE TUBES AND CYLINDERS
COPPER INGOTS. BARS. SHEETS &c ELECTRO-COPPERING.

OFFICES: MANCHESTER. BRANCH OFFICES LONDON AND GLASGOW.

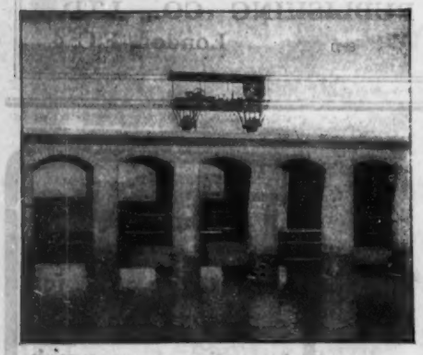
MANCHESTER. 8819

BRIGHT BARS. 8441

'PHONE: GOVAN 653-654. TELEGRAMS: "PEDESTAL, GLASGOW."

GOVAN SHAFTING & ENGINEERING CO., LTD., GLASGOW.

RANSOMES & RAPIER, Ltd.,



Isna Barrage (on the River Nile). View showing one of the Oil-engine-driven Travelling Crabs used for operating the Sluices.

SOLE MAKERS OF THE
"Stoney Control Sluices."
With Stokes' Patent Improvements.

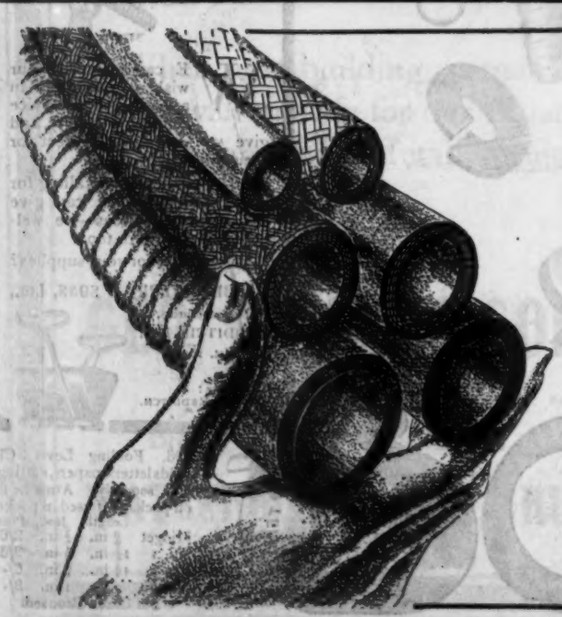
The "Free-Roller" or "Stoney Sluice" is absolutely reliable and simple, the cost of upkeep is exceedingly small and it will operate with certainty, whenever required, against any head for which it is designed.
It can be so protected as to ensure successful operation under ice conditions, in cold situations.
By its use the original régime of a river can, in times of flood, be restored in a few minutes.

SPECIALISTS in Water Controlling Apparatus as applied to Waterworks, Irrigation, Tidal Rivers, Water Power Installations, Navigation, Drainage, &c., &c.

The "STONEY" Sluice is in successful operation in most parts of the World. Over 1000 Sluices already installed.

(Dept. H.),
32, VICTORIA ST., LONDON, S.W.
Telegrams and Cables—Ransomes Rapier, London. Sluice, London. ABC, 5th Edition.
Telephones—4891 & 4892, Victoria. 904 Ipswich. O 7256

Eastham Sluices—Manchester Ship Canal. Span of each Gate 30 ft. Depth of each Gate 26 ft. Span of each Lift 36 ft.



HIGH GRADE HOSE

for every condition of service.

WE have had 60 years' experience in the production of Hose of all types and sizes—Delivery, Steam, Hydraulic and Suction Hose, both plain and armoured.

We are prepared, if necessary, to design and make hose specially to meet your own particular requirements.

SILVERTOWN HOSE

cannot be surpassed for quality, durability and reliability in service.

ENQUIRIES INVITED.

THE INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS CO., Ltd.
(THE SILVERTOWN COMPANY). 8512

Head Office: 106, Cannon Street, London, E.C. 4.
Works: Silvertown, London, E. 16.

Several Complete Sawmill PLANTS of MACHINERY FOR DISPOSAL, suit Home, Colonial or Foreign timber, large output, low prices.—Apply, ENGINEER, Mytholm House, Hebden Bridge. K 876

Three High Pressure Lancashire BOILERS, 30 ft. by 7 ft. 6 in. dia., complete with all fittings, for 200 lbs. working pressure. Available at once.—HARRY H. GARDAM AND CO., LTD., Staines. K 700

750 Kw. Belliss & Morcom Triple Expansion GENERATING SET, Dick Kerr Alternator (direct coupled), 2300 volts, 60 periods, single phase, latest type, Condensing Plant available if required.—Seen HARRY H. GARDAM & CO., LIMITED, Staines. K 30

Latest Type 1050 K.W. TURBO GENERATOR (low pressure) and CONDENSING PLANT, 50 periods, 3 phase, 6,000 volts, Asynchronous squirrel cage rotor. Contra-flo Condensor by Richardson Westgarth, complete with all accessories, including Switchgear, two Identical Sets available.—HARRY H. GARDAM & CO., LTD., Staines. K 130

For Sale, 400 HP., 500 volts, 50 cycle, 425 r.p.m., 3-phase slip ring motor by Westinghouse.—THE PHŒNIX ELECTRICAL CO., LTD., 33-36, Broomielaw, Glasgow. H 652

For Sale, Two Motor-driven 3-throw Hydraulic Pumps 53½ gallons per minute at 2240 lbs. pressure, geared to 150 HP. 415 volt, 50 cycle, 3-phase "B.T.H." motors complete—THE PHŒNIX ELECTRICAL CO., LTD., 33-36, Broomielaw, Glasgow. H 650

Transformers for Sale.— Three New 1875 K.V.A. 6600/440 volt, 50 cycle, 3-phase "Berry" Oil Cooled Transformers. THE PHŒNIX ELECTRICAL CO., LTD., 33-36, Broomielaw, Glasgow. G 475

For Sale, Three Phase Motors, 440 volts, 25 cycles, 50, 75, 100, 200, 23 , and 250 HP.—THE PHŒNIX ELECTRICAL CO., LTD., 33-36, Broomielaw, Glasgow. H 661

For Sale.

Two 850 Kw. "Fraser & Chalmers-Siemens" TURBO-ALTERNATORS, complete with Condensing Plant, Motor-driven Pumps, etc., etc. All new in 1916. Alternators can be arranged for 500-550 or 3000-3300 volts, 3-phase, 50 cycles. THE PHŒNIX ELECTRICAL CO., LTD., 33-36, Broomielaw, Glasgow. J 631

Pulleys.—Quantity of useful Cast and Wrought Iron Pulleys FOR SALE. For prices and particulars write, D. HENDERSON AND SONS, St. Saviours Rd. East, Leicester. L 174

Vertical Boilers in Stock.— 9 ft. by 4 ft. dia., 8½ ft. by 3½ ft., 7½ ft. by 30 in., 7 ft. by 3 ft. All with Cross-tubes. 8215 THE GRANTHAM BOILER & CRANK CO., Ltd., Grantham.

A Time Recorder, as New, guaranteed, latest model. WHAT OFFERS?—A. G. PELLEY, 149, Farringdon Road, E.C. 1. F 599

For Sale.

CONTRACTORS' SURPLUS PLANT.

Various Locomotives 8 in., 9 in., 10 in., 12 in. and 15 in. cylinders 3 ft. and 4 ft. 8½ in. gauge by Hudswell Clark and Manning Wardle. Excavators—No. 28 Model Marion Steam Shovels, 1¼ yd. "Hero" Steam Shovel. Two Ruston Proctor Tower Type Excavators. Loco. Cranes—4, 5, 7 and 10 ton std. gauge Loco. Cranes by Stothert and Pitt, Coles, Smith and Chaplin.

Concrete Mixers—various capacities with or without Petrol Engines and Elevating Hoppers by Stothert and Pitt, Ransomes, &c. Power Pumps—No. 6, 8 and 9 Pulsometer, 6 in., 8 in., 9 in. and 10 in. centrifugal and 8 in. and 10 in. Tangye.

Standard gauge Wagons—about 30 Main Line Trucks (High Sided) and 100 Ballast Wagons (Drop Sides).

Full particulars of any of the above on application to

SIR ROBERT McALPINE & SONS, 50, Pall Mall, S.W. 1. L 293

MISCELLANEOUS.

THE GLASGOW ROLLING STOCK AND PLANT WORKS

Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT. FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS. Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od 3382

R. Y. Pickering & Co., Ltd., (ESTABLISHED 1864.) BUILDERS of RAILWAY CARRIAGES & WAGONS. MAKERS of WHEELS and AXLES of all kinds. RAILWAY WAGONS FOR HIRE. Chief Works and Offices: WISHAW, near GLASGOW. London Office: Od 3383 3, VICTORIA STREET, WESTMINSTER, S.W.

Cheap Artistic Printing.-1000 Billheads from 6s. 6d. upwards. Letter Heads, Tags, Cards, &c. Samples free.—CRITTHWAY PRESS, Buxted, Sussex. K 999

STEAM TURBINES.

Richardsons, Westgarth & Co. Ltd.

HARTLEPOOL, MIDDLESBROUGH & SUNDERLAND.

See large Advertisement, Dec. 10. 7809

DROP FORGINGS

OF EVERY DESCRIPTION INCLUDING

SPANNERS

OF SUPERIOR QUALITY.

BRETT'S STAMPING Co. Ltd.

HARNALL LANE,

COVENTRY.

CONTRACTORS TO H.M. GOVERNMENT, WAR OFFICE AND ADMIRALTY.

Telegrams: "Brett's, Coventry." Telephone: No. 168.

CARRUTHERS

MARINE AUXILIARIES

POLMADIE IRON WORKS. GLASGOW.

8499

A. BEEBEE,
Studs, Bolts, Nuts, &c.
WEDNESBURY. 3469

RAWHIDE PINIONS
. . and . . 7984
Cast Iron Spur Wheels.
The REAY GEARWORKS, Ltd.,
GATESHEAD-ON-TYNE.

CROWN BOILER COVERINGS
THE COOLEST AND STRONGEST IN USE.
96% EFFICIENCY
SUTCLIFFE BROS,
Soho Works, 5166 Seal Wharf,
Godley, near Manchester. Stratford, E. 15.

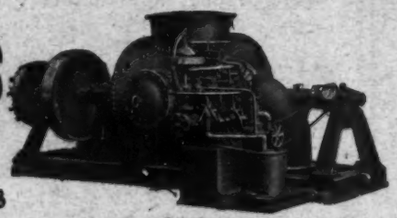
THOMAS SHANKS & CO.
Johnstone.
FOR
HEAVY MACHINE TOOLS
SEE ILLUSTRATED ADVERTISEMENT ISSUE OF DEC. 3.
7356

A. Reyrolle & Co., Ltd.
8793
Switchgear. *Hebburn-on-Tyne.*

Sturtevant Fans
Sturtevant Engineering Co., Ltd.
147, Queen Victoria Street,
LONDON, E.C.
Ask for List No. Eg. 1833

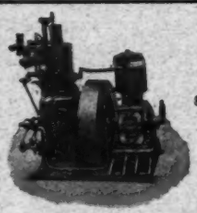
"WHITE'S INJECTORS" LIMITED.
THE GREATEST RANGE OF
INJECTORS & EJECTORS IN THE KINGDOM.
MANCHESTER.

WATER
TURBINES
AND
Pelton Wheels.
W. GUNTHER & SONS
CENTRAL WORKS, OLDHAM.


Gunther-Francis Turbine with Oil Governor

BECKENHAM FOUNDRY
BECKENHAM, KENT. Telephone No. 883 Sydenham.
PROMPT DELIVERY
of CASTINGS in
8864
ALUMINIUM, BRASS, GUN-METAL, PHOSPHOR BRONZE.

LANCASHIRE
BOILERS
IN STOCK & PROGRESS FOR EARLY DELIVERY.
WILLIAM WILSON & CO., 7416
LILYBANK BOILER WORKS, **GLASGOW.**



AIR COMPRESSORS.
Capacities from 1 c. ft. to 300 c. ft. free air per minute,
BELT, STEAM, ELECTRIC and OIL DRIVE.
8836
VACUUM PUMPS.
DIVING APPARATUS
of all patterns.
OXYGEN BREATHING APPARATUS for Work in Poisonous Air.
SMOKE HELMETS. MEDICAL OXYGEN APPARATUS.
SIEBE, GORMAN & CO., Ltd.,
"Neptune" Works and 187, Westminster Bridge Road, LONDON, S.E.
IMMEDIATE DELIVERY.
Telegrams: "SIEBE, LAMB, LONDON." Cables: "SIEBE, LONDON." Telephone No.: HOP 3401 (2 lines)

BELMONT IRON WORKS
PHILADELPHIA | NEW YORK | EDDYSTONE
Engineers · Contractors · Exporters
BELMONT IRON WORKS FOUNDED 1870 BEL-IRON INCORP. 1897 PHILADELPHIA
STRUCTURAL STEEL
Complete Industrial Buildings
STANDARD BEL-IRON BUILDINGS
MAIN OFFICE & WORKS, PHILA.: 22nd and Washington Ave., U.S.A. NEW YORK OFFICE: 32 PARK ROW.
CABLE ADDRESS: "BELIRON." Code: Western Union Five Letter Edition.
Illustrated Catalogue in English, French and Spanish mailed on request. Complete warehouse stock structural shapes and plates ready for immediate shipment. 8593

YOUNGS, RYLAND STREET WORKS, **BIRMINGHAM.**
MAKERS
HYDRAULIC TOOLS
AND
LIFTING TACKLE
FOR ALL PURPOSES.
WRITE FOR LIST
No. 7.

HYDRAULIC LIFTING JACK.

CRAB WINCH.

RIBBED BOTTLE TRAVERSE JACK.

JIM CROW.
8516

HOISTS
for every purpose, 8341
STEAM AND ELECTRIC
Send for Catalogues and Particulars.
LIDGERWOOD MANFG. CO.,
Friars House New Broad Street, LONDON, E.C.

THE
VAUGHAN CRANE
Co., Ltd., Manchester.
Travelling Cranes—Runways—Pulley Blocks.

STONE AND COAL CRUSHERS
ENG.
LEICESTER
GOODWIN BARSBY & Co

BRICK MAKING MACHINERY
Herbert Alexander & Co
Charlotte St.
LEEDS.

ELECTRO-MAGNETIC CHUCKS
FOR ACCURATE GRINDING.
RAPID MAGNETTING MACHINE CO., Ltd.,
CRESCENT, BIRMINGHAM. 9536

Ransome Machinery Co. (1920) Ltd.
14-16, GROSVENOR GARDENS, LONDON, S.W.1
CONCRETE MIXERS, HOISTS, TIPCARTS
TAR MACADAM & ASPHALT MACHINES,
STEEL PILING AND PLANT.

Measure your Screw Gauges accurately by using
B-L CYLINDERS & PRISMS.
Illustrated Booklet containing full particulars and prices post free from the makers,
BASSETT-LOWKE, LTD. NORTHAMPTON. 8766

FOR FULL STROKE DUPLEX PUMPS, WRITE FOR OUR NEW LEAFLET. 8549
TWELLS' PATENT VALVE GEAR (DUPLEX PUMP) CO., Tudor Chambers, 25, Millstone Lane, Leicester.

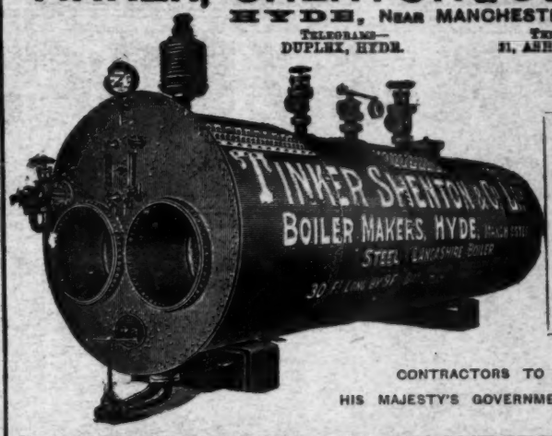
CAMPBELL & CALDERWOOD,
Soho Engine Works,
PAISLEY,
SCOTLAND.
LAND & MARINE ENGINES
7706
See Illustrated Advertisement Last Week and Next Week.

CONTRACTORS' PLANT.
CRANES.
PILE DRIVERS.
Whitakers (Engineers) Limited,
HORSFORTH, LEEDS. 6909

CASTINGS.
Gunmetal—Phosphor & Manganese Bronze, &c
Engine and Boiler Mountings.
Lighthouse and Fog Signal Engineers.
STEVEN & STRUTHERS
GLASGOW, SCOTLAND. 8043
See our Illustrated Advertisement on Dec. 24 and Jan. 21.

PULSATING PUMPS
TURNSTILES,
AND GENERAL ENGINEERING.
W. T. ELLISON & CO., Ltd.,
Irlams'-o-th'-Height,
MANCHESTER.
Telegrams:—"Ellisons Ltd., Irlams'-o'th'-Height.
Telephone: No. 36, Pendleton. 6806

"SHONE"
PNEUMATIC EJECTORS
For RAISING SEWAGE, SLUDGE, PAIL CONTENTS, &c.
AS USED AT
RANGOON, KARACHI, BOMBAY, EASTBOURNE, NORWICH, GOSPORT, HOUSES OF PARLIAMENT, Westminster, and many other places.
AIR COMPRESSING MACHINERY
COMPRESSED AIR LIFTS For Raising Water from Wells, Boreholes, &c.
For Pamphlets and full particulars apply to the Manufacturers—
HUGHES & LANCASTER, Ld., 16, Victoria St., LONDON, S.W. 7764

TINKER, SHENTON & Co. LTD.
HYDE, NEAR MANCHESTER.
TELEGRAMS—DUPLEX, HYDE. TELEPHONE—21, ASHTON-U-LYNE.


MAKERS OF HIGH-CLASS LANCASHIRE CORNISH AND ALL OTHER TYPES OF **BOILERS**
CONTRACTORS TO HIS MAJESTY'S GOVERNMENT. 8175
All holes drilled out of the solid plate, and the pitch of rivets set out by patent automatic dividing apparatus. Welding, flanging, planing, riveting, &c., by **Special Machinery** of the most modern construction. **Riveting** all done by hydraulic power constructed so that the pressure on the rivet can be regulated from 30, 50 and 80 tons, according to the diameter of the rivet and the thickness of the plates. This is a most important feature in the construction of high-pressure boilers.
SOLE MAKERS OF THE "ACCESSIBLE" STEAM SUPERHEATER.

THOMAS BOLTON & SONS, LTD.
Established 1783.
COPPERSMELTERS & MANUFACTURERS.
Contractors to His Majesty's Government.
COPPER
PLATES, SHEETS, STRIP, ROD, TUBES, WIRE.
Copper Calico Printing Rollers
WORKS—
OAKAMOOR, NORTH STAFFORDSHIRE. FROGHALL, NORTH STAFFORDSHIRE.
MERSEY COPPER WORKS, WIDNES. SUTTON ROLLING MILLS, ST. HELENS.
LONDON OFFICE; 168, Regent Street, W. 1
(W. Lee Mathews, London Director).
Telegraphic Address:—WIREDRAWN, LONDON. 8855

STEEL CASTINGS
STEEL AND IRON FORGINGS.
THE DARLINGTON FORGE LTD.,
DARLINGTON. 7698
Tels: "FORGE, DARLINGTON." Tel. 3618.
(*See advertisement, page 99, Dec. 24*).

Central Exhaust and Heat Extraction
STEAM ENGINES
DIESEL OIL ENGINES
CONDENSING PLANTS
POWER INSTALLATIONS
Cole, Marchent & Morley, Ltd.
Bradford, Yorks.
Display advertisement page 143, December 10.

KAYE'S
LATEST PATENT
SERRATED SEAMLESS STEEL OILCAN.

Fitted with New Patent Thumb Bottom, Seamless Spout, and Slide Feed Hole.
Also in COPPER or BRASS,
FOR
ELECTRICAL PURPOSES.

9008
Contractors to H.M. Navy, War Dept., Home Office, and Indian State Railways.
SOLE MAKERS:—
Joseph Kaye & Sons
LTD.,
LOCK WORKS, LEEDS
Governing Director: W. K. KAYE, M.I.Mech.E.
And 93, HIGH HOLBORN,
LONDON, W.C.

DELIVERY FROM STOCK.

"MARSHALL"
TRACTION WAGONS
SIZES 4, 6 & 8 TONS.
Also LIVING & SLEEPING VANS
(The most comfortable and convenient Vans on the market.)
MAY WE QUOTE YOU? 8896

Ask for our Firm Prices and Specifications.
Mention "ENGINEERING."

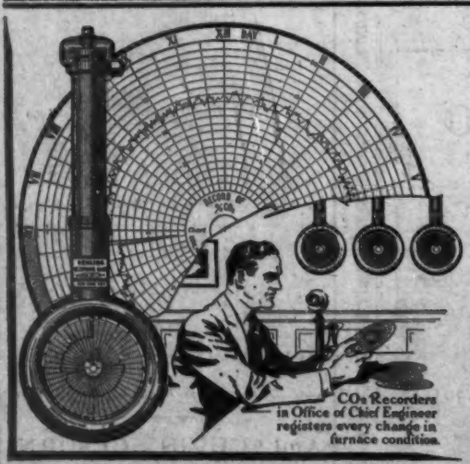
MARSHALL, SONS & CO., Ltd., GAINSBOROUGH.

ELECTRIC, STEAM, AND HYDRAULIC
CRANES
GEORGE RUSSELL and CO., Ltd., MOTHERWELL N.B. 8366

The Best Pump
Trade Mark.
The Pulsometer
Steam Pump
for General Use.
Write for List No. 7.

Telegrams—
Pulsometer, Reading.
Pulsometer, London.
Pulsometer Engineering Co., Ltd., 8535
LONDON:
Offices, 11, Tothill Street, Westminster. S.W.
READING:
Works,
Nine Elms Iron Works.

BRIGHT COMPRESSED
SHAFTING 3674
ROUNDS. HEXAGONS. FLATS. SQUARES
KIRKSTALL FORGE LTD., NEAR LEEDS.



CO_2 Recorders in Office of Chief Engineer registers every change in furnace condition.

Check
FUEL WASTE

By far the largest boiler room waste is the heat discharged up the chimney. UEHLING CO_2 Equipment keeps tabs continuously (not intermittently) on this waste, thus enabling the engineer and firemen to co-operate in reducing it. UEHLING CO_2 Equipment is simple in principle and operation and uses no chemical solutions.

Write for New Catalogue.

UEHLING
INSTRUMENT COMPANY,
Combustion Engineers, 8243
2020, Empire Building, NEW YORK, U.S.A.

CO_2 Indicator for boiler front guides the fireman in saving coal

Printed for the Proprietors by HARRISON & SONS, LTD., at the Bedford Press, 20 & 21, Bedfordbury, in the Parish of St. Martin's-in-the-Fields, and Published by CHARLES ROBERT JOHNSON, at the Offices of ENGINEERING, 35 & 36, Bedford Street, in the Parish of St. Paul, Covent Garden, both in the County of Middlesex.—December 31st, 1920.